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THAILAND NATIONAL PROGRAMME

OF THE

EARTH RESOURCES TECHNOLOGY SATELLITE

Sanga Sabhasri

Secretary-General

National Research Council

Bangkok 9, Thailand

July 1977

Type III Final Report for Period June 1975 - July 1977
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National Research Council
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Thailand

Goddard Space Flight Center
Greenbelt,
Maryland 20771
U.S.A.

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12. National Research Council 196 Phahonyothin Road, Bangkhen Bangkok 9, Thailand		13. Multidisciplinary Resources Surveys, National
14.	Original photography may be purchased from: EROS Data Center [redacted] Sioux Falls, SD 57198	ORIGINAL CONTAINS COLOR ILLUSTRATIONS

15. This report contains an introductory sketch covering major events, results of analyses conducted in several disciplines by user agencies (agriculture, forestry, land use, geology, water resources), statements of current status and future plans, and summaries of ongoing research and data utilization projects. Landsat-1 and Landsat-2 image interpretations that have been verified by ground surveys and/or aerial reconnaissance flights are illustrated.

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PREFACE

1. Objectives

The overall objective of the Thailand National Program is to produce, based on satellite data, an up-to-date and accurate information required for planning for development and management of natural resources at the national level. The LANDSAT-2 program is an ERTS-1 follow-on program with refinements and revised objectives derived from experience with ERTS-1 data.

2. Scope of Activity

Subsequent to activities reported earlier in ERTS-1 Final Report, in May 1974, a sub-regional Seminar on ERTS and Southeast Asia was organized by the National Research Council and the Applied Scientific Research Corporation of Thailand with assistance from USOM, U.S. Information Service and NASA. Scientists from Indonesia, Malaysia, Singapore and Laos participated in the seminar to exchange information on the application of Landsat-1 data, and to listen to lectures given by NASA experts on latest development in sensors, systems and applications in the U.S. and elsewhere.

Another training workshop, the second in a series organized with assistance from USOM and USGS, was held in January - February 1976 at the NRC/ASRCT. It consisted of a Basic Part and an Advanced Part. The Basic Part was intended for beginners in remote sensing, whereas the Advanced Part was geared towards investigators who had basic background and some working experience with Landsat imagery, and were given by U.S. and Thai experts.

TNRSP recently organized the latest seminar on applications of Landsat-2 data to national development during June 23-29, 1977. The participants were lecturers in the universities and officials from various departments. The language used in the seminar was Thai. Results of the current Landsat follow-on investigation were discussed. TNRSP, with the cooperation of the Asian Institute of Technology (AIT) will hold a workshop on automatic data processing (ADP) of Landsat CCT's at AIT Regional Computing Center this year. This workshop is intended for Thai government officials to evaluate the potentials of ADP for analysis of remote sensing data.

The training of personnel at advanced institutions, especially in the U.S., is equally important. More than twenty Thai scientists have undergone training in remote sensing in the U.S. and more opportunities are being planned.

With the completion of a new two story building at the NRC/ASRCT compound in December 1976, the facilities and capabilities of the TNRSP have been greatly enhanced. The ground floor consists of offices of TNRSP Working Unit, a library, user service room, data handling and storage room,

interpretation room, instrumentation room and photographic laboratories. The first floor is devoted mainly to a large conference room with seating capacity of two hundred and fifty and can be partitioned into several smaller rooms for training purposes. Such facilities have been offered to UN bodies and neighbouring countries for holding of seminars and workshops as well as in-house training in remote sensing. The current capability of TNRSP includes the reproduction of black and white prints of Landsat imagery at scale of 1:1 million, 1:500,000 and 1:250,000 from the original 70 mm negatives, and diazochrome colour composites at 1:1 million scale. Preparation is being made to enable production of color composite prints at 1:1 million scale and possibly at larger scale in the next six months.

The Working Unit performs coordination function of TNRSP and is supportive of other government agencies that are involved in single resource studies such as forestry, land use, agriculture, geology, etc. Although some studies are being conducted by the Working Unit, its main function lies in the provision of user assistance to other agencies including reproduction of Landsat imageries, equipment for analysis, compilation and translation of research results into reports, provision of research grants and organizing training workshops and seminars.

3. Significant Analyses, Findings and Techniques

(1) Agriculture

The Department of Agriculture has been using Landsat imagery as base maps in many areas. Some accomplishments include the identification of a series of active alluvial fans along the margins of the Central Plain, the compilation of crop resources maps of Central and Eastern Thailand, and evaluation of the Purdue/LARS printout using unsupervised mode of an area near Bangkok. Current activities center around the mapping of rubber plantation area and the use of machine processing for improved crop differentiation and cover-type identifications.

Color composites at scale of 1:250,000 were found to be very useful for mapping of rubber plantation areas. The study was carried out for two test sites, one in the Souteastern Coast and another in the Peninsula area. The results obtained show possibility of using Landsat imagery in the identification and mapping of rubber plantation areas.

(2) Forestry

The activities at the Royal Forestry Department include the inventory of existing forest land in the Kingdom, the Skylab investigation in forestry, the watershed management of tributaries of Chao Phya River, and the identification of shifting cultivation in northern Thailand, Results obtained using Landsat-1 imagery and ground truth survey showed that Thailand's existing forest in 1973 covered an area of approximately 37 % of total land area. The last country-wide survey using aerial photographs at 1:60,000 scale conducted in 1961 gave the figure of 58%. The use of

satellite data has proved the timeliness and economic benefits over the conventional aerial survey. Attempts are being made to differentiate different types of forest using B & W prints and diazochrome transparencies with some success. Automatic data processing is being planned to test the advantages of machine processing over photointerpretation method and the cost involved.

(3) Land Use

Both black and white prints at 1:500,000 and 1:250,000, and color composites at 1:1,000,000 scale were used for general land use classification. A large portion of the country covering an area of 170,011 sq.km. had been mapped using Landsat imagery with ground truth survey. Current plans call for more refined classification using automatic data processing and mapping of the remaining area as well as change monitoring.

In addition to land use classification of North Thailand carried out by the Land Development Department as mentioned above, the Faculty of Forestry of Kasetsart University has conducted a study titled "National Resources Evaluation of Khao Yai National Park Using Landsat Imagery". The purposes of the study include, among other things, the investigation of the existing land-use of Khao Yai National Park using mainly Landsat data, the determination of changes and impact of the study area and the evaluation of the validity of Landsat imagery in tropical forest/agriculture land-use classification and tropical forest ecological studies. Land use maps were prepared and field surveys were conducted to verify the result of photointerpretation. It is evident from the study that forested area of Khao Yai National Park is very well protected; the rate of forest depletion in this area is very small, only about 0.45 % per annum. However, the forest depletion rate in the surrounding area is much greater; namely, 3.77 % per annum. Such data served to alarm the government on the critical situation of deforestation in Thailand, and, as a result, the government has embarked on a National Forestation Program aiming at increasing the percentage of forest land. It is hoped that Landsat-C could assist in the monitoring of the results of the current forestation program.

The Working Unit of TNRSP also conducted a research project on land use and forest study of Northeast Thailand from color composite print processed by IBM computer. The ground truth data acquired showed 98% accuracy of the interpretation among 103 selected sampling plots. Although various types of cultivation and forest could not be classified, the color enhancement of small features were displayed.

(4) Geology

The Department of Mineral Resources has conducted studies into the applications of photogeologic interpretation techniques to Landsat imagery. Black and white positive transparencies of MSS band 7 were used for most of the work. Field survey was also carried out to verify the results of the interpretation. Experience to date has shown the many advantages of Landsat imagery over the conventional aerial photography in locating large faults and fractures and in the preparation of tectonic maps. Several rock

types can also be identified from Landsat imagery.

(5) Hydrology

The imagery of the Central Plain of Thailand during the flooding stages were taken by Landsat-2 on the request of Thailand to NASA. The study was carried out to determine the flooded areas. Of all the cloud free area of 11,400 sq.km., the flooded area was found to cover an area of 2,235 sq.km., largely in the low lands.

4. Conclusions

The investigations conducted by Thailand using Landsat-2 imagery further confirmed the results of the Landsat-1 investigations of the benefits of satellite remote sensing for assessment of natural resources and for monitoring of environmental change which were vital to resources inventory, planning, and management at the national level. Research and development in several disciplinary areas led to more refined study in a wider range of applications on the one hand, and quasi-operational projects on the other. Since practical applications have been established in agriculture, forestry, land use, geology and hydrology, expanded activities in utilizing satellite remote sensing have taken place. The planning agencies, such as, the National Economic and Social Development Board (NESDB) has taken great interest of the potential and capability of remote sensing to provide a vital input to natural resources planning purposes. With availability of regular and timely data from the resource satellite, many existing investigations and research projects could become operational. Such conclusion has been reached by decision-makers and Thailand has decided to go ahead with the plan for the establishment of a Landsat-type ground receiving station so that continuous data could be received. Government contribution will be greatly enhanced in the near future to enable Thailand to benefit as much as possible from this new technology of remote sensing.

5. Problems and Recommendations

It is unfortunate that many Landsat-2 imagery of Thailand were covered with clouds. Some of the imagery with less than 70% cloud cover were not sent to us promptly eventhough the standing account established with EROS Data Center were still effective. Besides, the price of the data products have gone up so high which may jeopardize the program in some areas. These problems have created slow-down in the project and the timeliness of the data were not realized. More and more investigators asked for computer analysis for detailed study and it is recommended that EDC should expand facilities to cope with this situation.

6. Major Future Plans

Thailand is in the process of planning the following:

(1) To further upgrade the facility and capability of the TNRSP in the area of user services in the dissimination and analysis of satellite

remote sensing data in-country with possible extension to cover other countries of Southeast Asia, with cooperation and assistance from USOM/AID.

(2) To establish a ground receiving station for direct reception of signal from Landsat and future resources satellites.

(3) To establish a data bank for resources data on a national and possibly on a regional scale.

(4) To acquire machine processing equipment for in-house automatic data processing of Landsat CCT's.

(5) To organize interregional workshops on remote sensing applications for development planning.

The Application of LANDSAT Imagery to Rubber Plantation Mapping in Thailand

by

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Ministry of Agriculture and Cooperatives

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Abstract

The main research objectives are twofold; first, to apply LANDSAT imagery interpretation methods to up-date the existing rubber plantation maps and, secondly, to test the possibility of using other remote sensing methods for rubber planting area identification. Two main test sites in the Southeastern Coast and Peninsula areas were selected. Various LANDSAT images at scale of 1:1,000,000 and 1:250,000 were used as base maps. Colour transparencies, false color composites and diazochrome techniques were employed. Field checking for surface information and data collection was carried out occasionally.

Three main principles, namely spectral, spatial and temporal changes of rubber areas were the basic principles used for the identification.

The results obtained lead to the following conclusions:

1. There is a great potential for using LANDSAT imagery in identification of rubber plantation area

2. The cost of operation and materials using LANDSAT imagery is considerably less than that of the conventional surveying methods.

3. The three main difficulties in using LANDSAT imagery are cloud cover, similarity of rubber plantation with tropical rain forest, and spatial characteristics of old rubber plantation areas.

4. Automatic data processing to identify and classify rubber plantation areas should be attempted.

I. Introduction

Remote sensing of environment is rapidly becoming a useful tool for natural resources survey and inventory. The recent trend of nonphotographic techniques, namely multispectral scanner, radar and other sensors is being employed in many successful surveys.

Utilization of LANDSAT imagery in agricultural surveys has been

found very advantageous in Thailand. Since the first batches of LANDSAT MSS imagery were supplied to Thailand, the agriculture sector of the Agriculture Department has been using color and black and white prints as base maps in many areas.

The study was carried out in three major phases; preparation, ground information collection, and analysis. The first phase included training of personnel by the U.S. team, test site selection, preparation of ground information forms, and contacting experimental stations near the test sites. The second phase was deveoted to ground information collection at various test sites and field checking for covertype boundaries. Aircraft observations were made on two occasions. Interpretation and data analysis were done simultaneously with field checking. The rubber plantation survey was attempted to test the usefulness of LANDSAT imagery in 1975. The result obtained indicated high possibility of using LANDSAT imagery in rubber plantation survey.

II. Basic Background

The fundamental concept of remote sensing is based on the fact that all natural phenomena transmit, absorb, emit and scatter electromagnetic energy at distinctive wavelengths. Each agricultural scene and different plant types exhibit their own characteristics and one may measure to obtain useful information by using a proper sensor at a proper wavelengths. The sensor systems may be divided into two broad categories, namely active and passive sensors. Active sensors refer to instruments that transmit some form of signal and record the magnitude of the return signal, such as RADAR, SONAR, Side Looking Airborne Radar (SLAR), Radiometer and Airborne Scintillation Counters. The other group of sensors are called passive sensors. These type of instruments record radiation reflected or emitted from the objects. Cameras, multispectral scanners and thermal infrared scanners are classified as passive sensors. The proper sensors together with spectral, spatial and temporal changes of the objects enable researchers in various disciplines to conduct many useful survey projects.

The most useful sensor of the Earth Resources Technology Satellite (LANDSAT) is the multispectral scanner which consists of 4 different wavelength bands ranging from band 4; 0.5 - 0.6 μ.m. (blue - green), band 5; 0.6 - 0.7 μ.m. (red), band 6; 0.7 - 0.8 μ.m. (infrared) to band 7; 0.8 - 1.1 μ.m. (infrared). LANDSAT-1 was launched on July 23, 1972, SKYLAB in 1972 and LANDSAT-2 in 1975; but the data being used were mainly obtained from LANDSAT. The satellite weight is about 1 ton on earth, the orbit is sun synchronous at altitude of 914 km, each imagery covering 34,000 (185 x 185) sq. km. and repeats scanning operation at the same location every 18 days.

III. Procedures

The rubber plantation mapping using LANDSAT imagery was initated in late 1975. The main objective was to test the possibility of using various LANDSAT data products to update the presently available maps. The

black and white prints at scale of 1:500,000 were first employed. The results obtained were unsatisfactory. Then various methods were attempted, namely, using 1:250,000 black and white prints, 1:1,000,000 diazochrome technique and 1:500,000 and 1:250,000 false color composites as base maps. The color using multispectral viewer were also tried in this project. The ground data collections were done occasionally depending on temporal changes of the rubber plantation areas, normally when the rubber trees shed their leaves or the young leaves formed on top of the trees (wintering). Those periods would show great differences in spectral response and one could separate rubber plantations from orchards and tropical rain forests at easier task.

Two test sites in different latitudes were selected. One is located in Rayong province in the southeast coastal area. The other is located in the Peninsula area. Each test site comprises an area about 2 x 2 square kilometers, within each there consisted more than 80 % of both young and mature rubber trees. Field observations were conducted at regular intervals, more frequent during the temporal changes of rubber trees. The final deliniation of rubber plantation on the false color composite imagery was done in the areas with comparison done against field checking results.

IV. Cost of Operations

The cost of operation at this stage of study consisted mainly of travelling expenses, per diem for officials and the cost of the imagery.

Interpretation Time and Approximate Costs of the Two Test Sites and Vicinity

Task	Time (Hours)	Manpower (man)	Costs (Bahts)
Ground Information Collections (1 Year) (Travelling, per diem)	20	4	10,000
Deliniation of Scenes	12	3	250
Interpretation (2 Scenes)	6	3	250
Cost of Color Composites			2,000
Miscellaneous			4,000
		total	16,500
		or	US $ 825

Note: US $ 1.00 is equivalent to 20.45 Baht

V. Results and Discussions

At present the most suitable imagery to be used as a base map for rubber plantation area is a color composite at scale of 1:250,000 which could be compared with the 1:250,000 topographic maps and presently available rubber plantation maps of the same scale.

The automatic data processing was tried successfully to identify the orchards and other economic crops in the Central Plain using LARS/PURDUE computer. The grey map of 1:24,000 scale proved to be very useful. The same system is being tested at the Asian Institute of Technolcgy. Considering the operational scale, using LANDSAT imagery is far more advantageous than the conventional aerial photograph survey. The combination of LANDSAT imagery, aerial photographs and ground data acquisition is highly recommended. In the future, the uses of the automatic data processing to identify and classify rubber plantation areas should be attempted.

In conclusion, due to the cost of the operation and facilities available in developing countries, the image oriented method based on the conventional aerial photograph interpretation should be used. However, when the automatic data processing facilities become available, we should then proceed to the numerical oriented procedures.

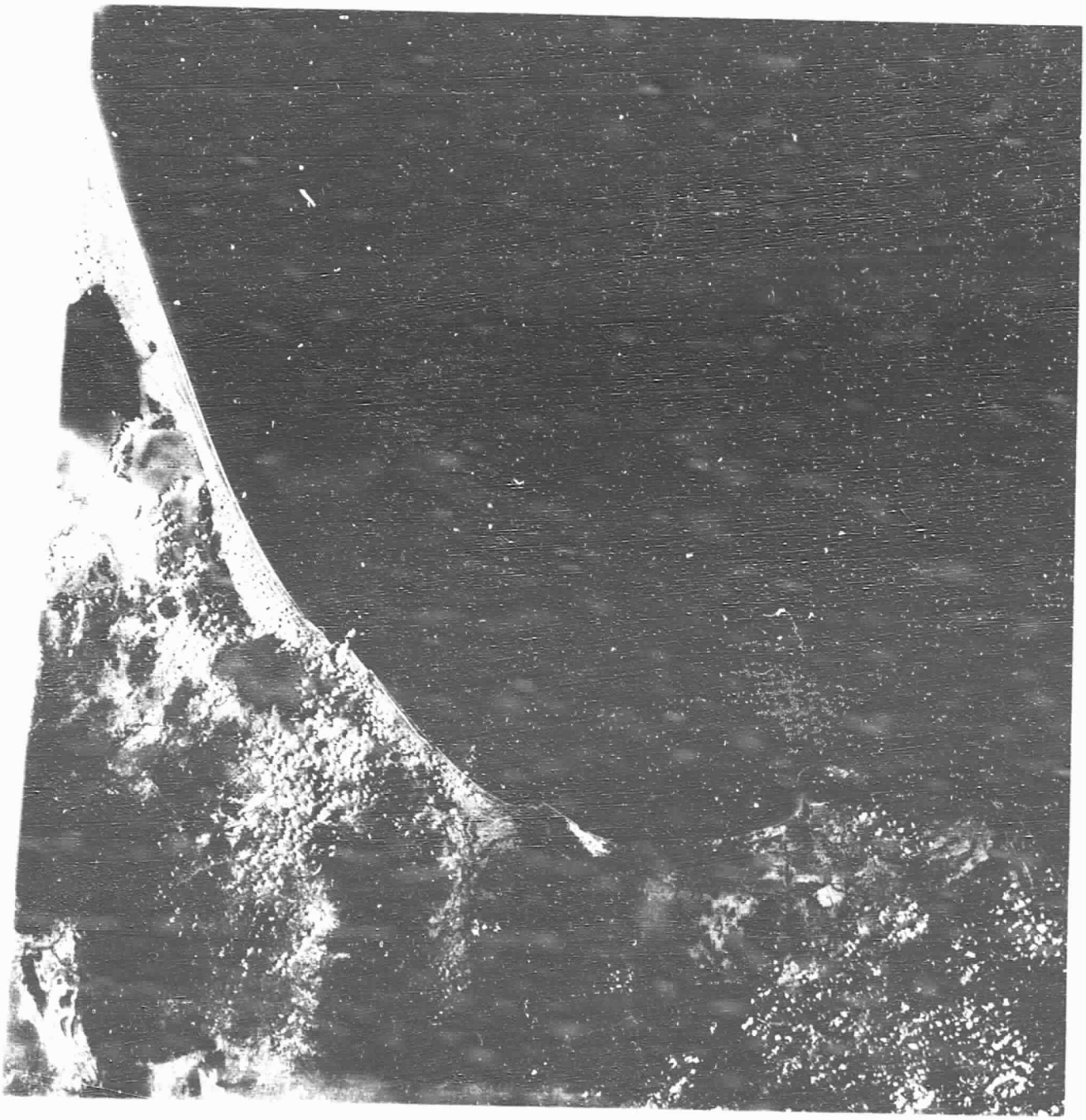


Fig. 1 : Landsat-1 image of South Thailand.

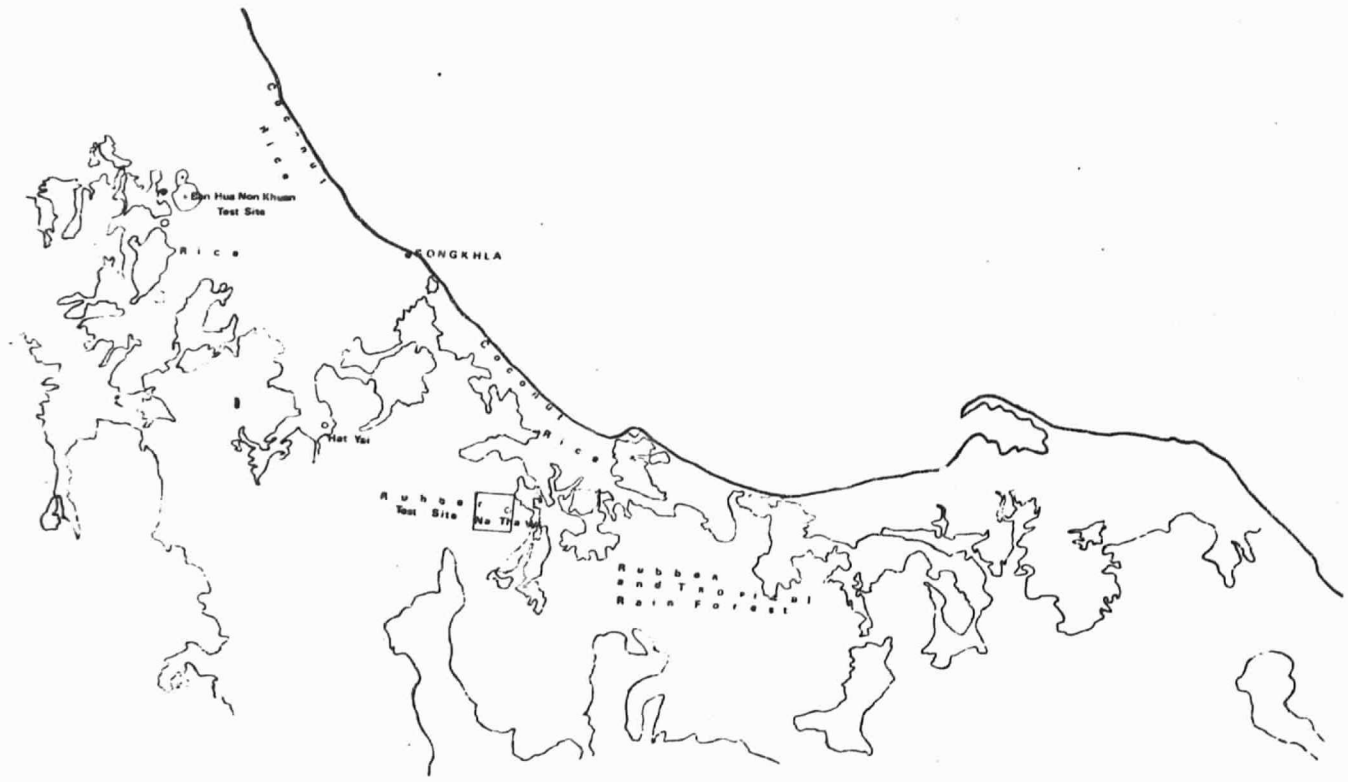


Fig.2 : Rubber plantation areas of the South as interpreted from Landsat-1 imagery.

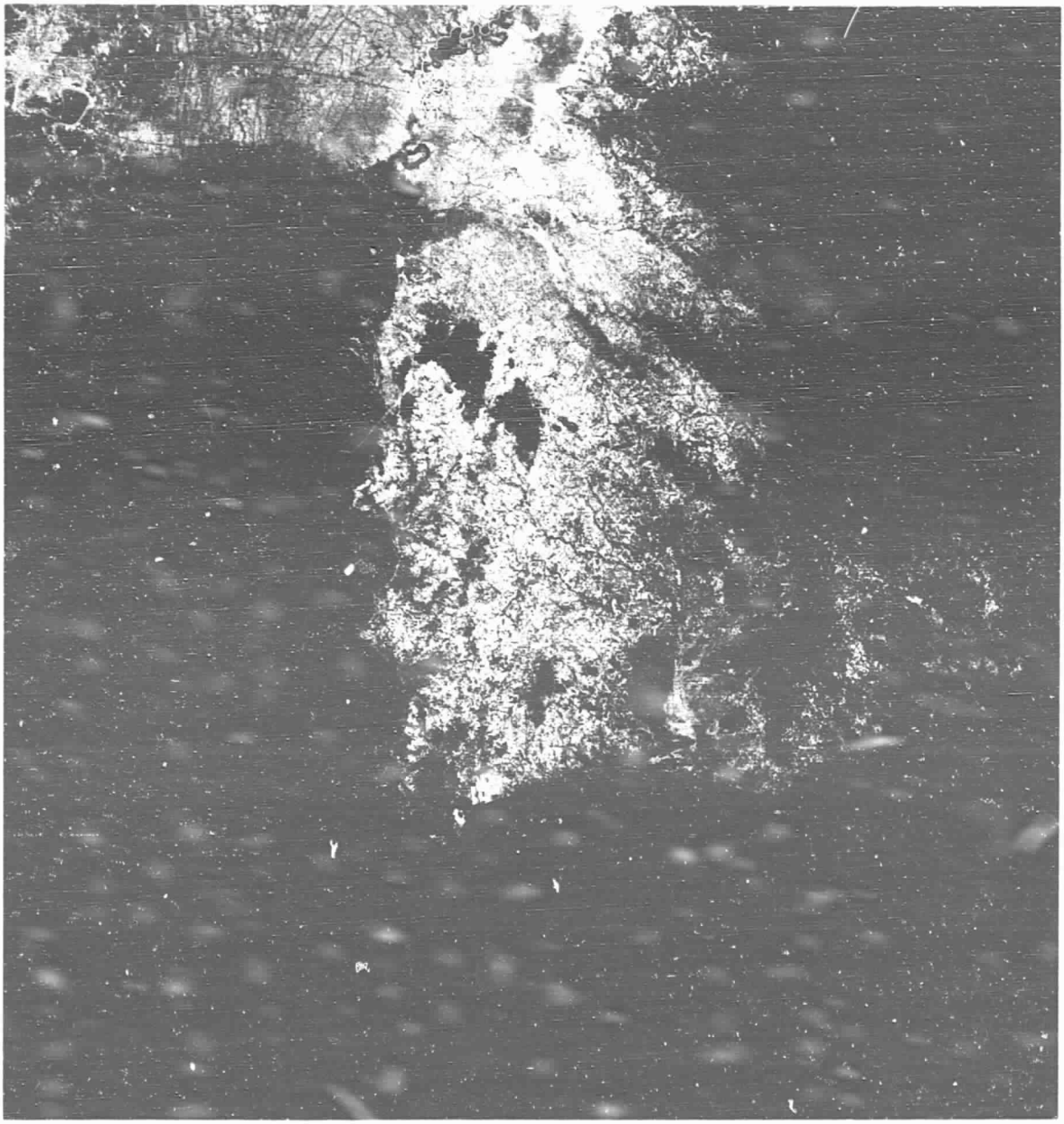


Fig. 3 : Landsat-1 image of eastern coast of Thailand

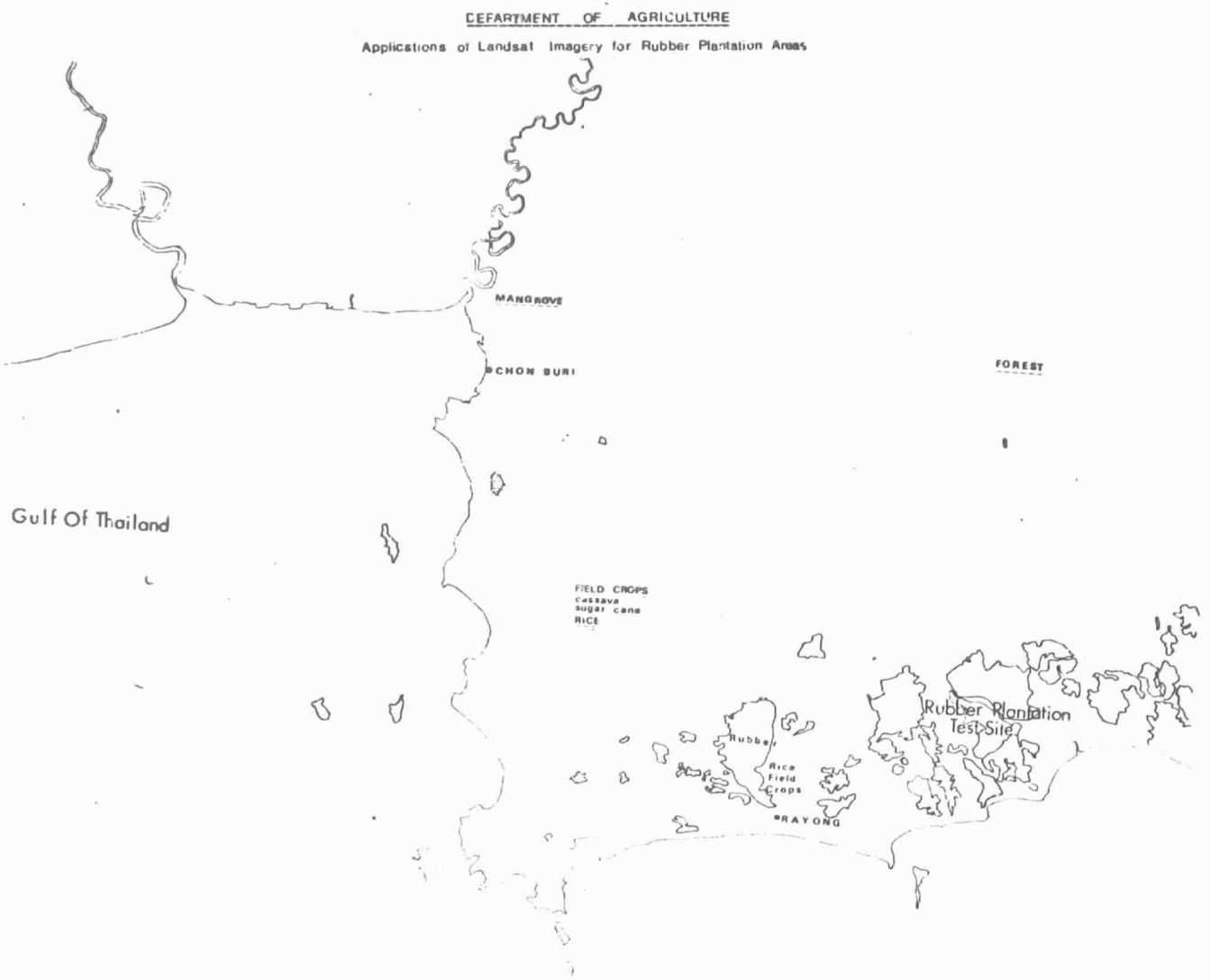


Fig.4 : Rubber plantation areas of eastern coast of Thailand as interpreted from Landsat-1 imagery.

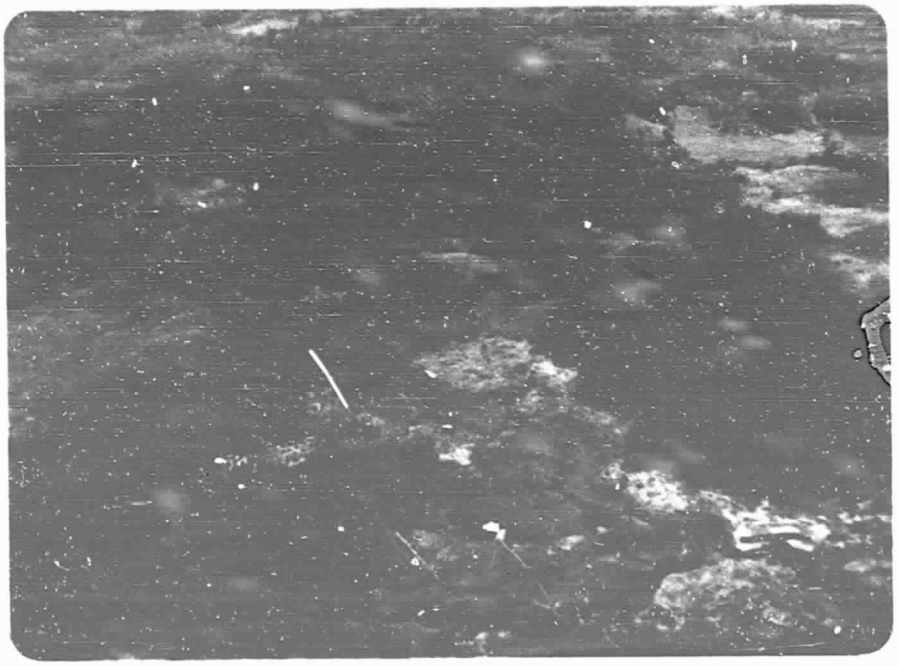


Fig. 5 : Rubber plantation areas taken from light air plane during ground truth survey.

Application of ERTS-1 Imagery in Forestry

Reported by

Dr. Chamni Boonyobhas and Boonchana Klankamsorn

Royal Forest Department

Summary

Study of forest inventory by using ERTS-1 imagery provides us with successful and satisfactory information on forests needed. This high accuracy application can save more times and manpower in surveying than that of the traditional method. Interpretation of ERTS-1 imagery indicate that the forest areas of the whole country covered approximately 38.61 % of land area by comparing with land use map and aerial photos. In addition, it also shows us the forest areas increased or decreased in each province of the country.

After studying and surveying the forest areas in various parts of Thailand, the maps of 5 parts were prepared out as follows:

1. Forest map of East Thailand
2. Forest map of Northeast Thailand
3. Forest map of North Thailand
4. Forest map of South Thailand
5. Forest map of Central Thailand

From study of ERTS-1 imagery, it is clearly evident that application of ERTS-1 imagery in forestry is a useful tool in surveying forest resources relating to the economic and social development of the country.

I. Introduction

Since the Royal Forest Department was a working group of the committee, ERTS imagery was applied in forestry to develop a new technique for forest management. A number of foresters were trained in Remote Sensing Techniques Programs in the United States and other Thai Forest Officers were also trained in ERTS Training Programs sponsored by NRC and USOM.

II. Objectives

About 40 % of the total area of the Kingdom is covered by forests, and all belong to the state. These forest areas are classified into various types such as Evergreen, Mixed Deciduous, Dry Dipterocarp, Mangrove and Pine Forests. The forest in Northern Region of Thailand are of Teak (Tectona grandis Linn.) bearing type. The forests are mostly tropical mixed forest with many valuable species. This type of forest is very dense with considerable under-storied plants and climbers, making ground inventory completely inaccessible.

Realizing that forest resources are directly as well as indirectly

beneficial to the economic and social development of Thailand, the Thai government in her 5-year economic and social development plan, set a policy of conserving 50 % (250,000 km^2) of the total area of the country as forest area. However, due to political, economical and social pressures, the forest condition is consistently deteriorated. The set goal has not been reached. There is, therefore, an urgent need to routinely monitor the forest resources so as to know exactly the existing forest area as an input to the optimum forest management planning.

The Royal Forest Department has applied Earth Resources Technology Satellite (ERTS-1) imagery for forest inventory and has developed reliable interpretation techniques which have proved cost-effective in providing more information and much faster data than traditional methods. In the initial phase, the main objectives are:

(1) The survey of existing forest area of the whole country.

(2) The designation of particular forest areas for conservation of watershed area.

(3) Assisting in the location of suitable forest areas to be used as self-help settlements (Forest community development) to provide additional crop land for the farmers.

III. Imagery and Instruments Used

(1) ERTS-1 imagery (Black and white) band 5 and 7 scale 1:500,000 covering the area of surveying of Thailand.

(2) Aerial photos scale 1:10,000 same area.

(3) Diazochromes scale 1:1,000,000 same area.

(4) Mirror stereoscopes.

(5) Magnifiers, tapes, and compasses.

(6) ERTS-1 Data Sheet.

(7) Vehicles for ground truth checking.

IV. Procedures of ERTS-1 Imagery Analysis

1. Interpretation The interpretation of imagery was made by using black and white bands 5 and 7 at 1:500,000 scale. These prints were covered with microtrace drafting paper and the boundaries of the test site areas were deliniated under the condition of tonal differentiation. The expected legends were first labelled by using the code. However, in order to improve the accuracy of space photograph interpretation, aerial photographs of any scale which covered the study area were brought in to assist in the recognition activity and additional details were taken from 1:1,000,000 scale diazochrome

false color composite transparencies (Fig. 1 and 2)

When the imagery had been stratified, the number and location of spot checks of various strata were based on the relative sizes of individual strata. However, from the economic point of view, the location of each spot check depends on the existing facilities and the convenience of transportation. Three ground control points were set up within each frame of space photograph, in order to control the shape of the map when transferring the details to the map and for checking certain details in the field. After interpretation activities has been completed, the stratification and legend labelling on each photograph were carried out as final activities.

2. Ground Checks This was done occationally at the test site areas. The location of the spot checks were guided by topographic map of scale 1:50,000 and 1:250,000 and various scale of aerial photograph. Within the test site area, the size of a 25 x 25 meters samples plot was assigned for research work (Fig. 3). All data within the test plots were recorded on the data sheet form, and then the photographs of forest profile were taken with ordinary 35 mm. cameras where there were variations in tone on the images of each test site area (Fig. 4 and 5).

The preliminary map was checked in detail again and the legends were corrected for accuracy. In the office, after the map had been checked, the completed and verified legends with the descriptions were entered on the map, and then the map was sent to the press.

The coded legends that were applied in the initial stage of interpretation could be classified as follows (Fig. 6).

01 = Vegetated area

02 = Cultivated area

03 = Urban area

04 = Water

05 = Open land

Finally, after the map had been checked, the symbolic legends were entered on the map (Fig. 7 and 8). For instance:

$$\frac{01.20.3}{M4/1}$$

3 = Type of Forest Disturbances (no disturbance)

M4 = Macrorelief (M4 = Mountainous land)

01 = Land use category

20 = Type of Forest (Dry Dipterocarp)

1 = Crown density (0-25 %)

DATA PLAN CHART

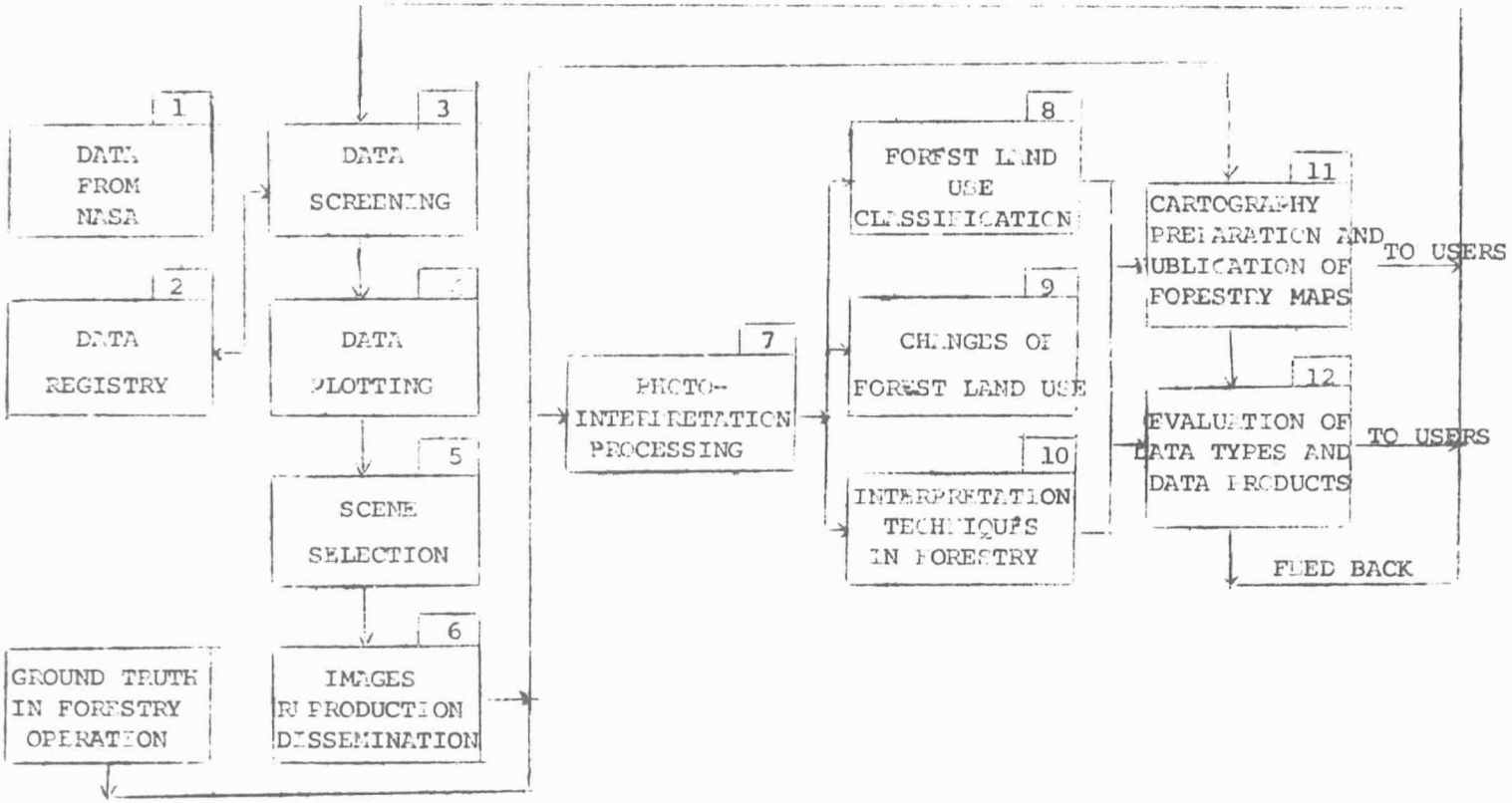


FIGURE 1: DATA PLAN CHART

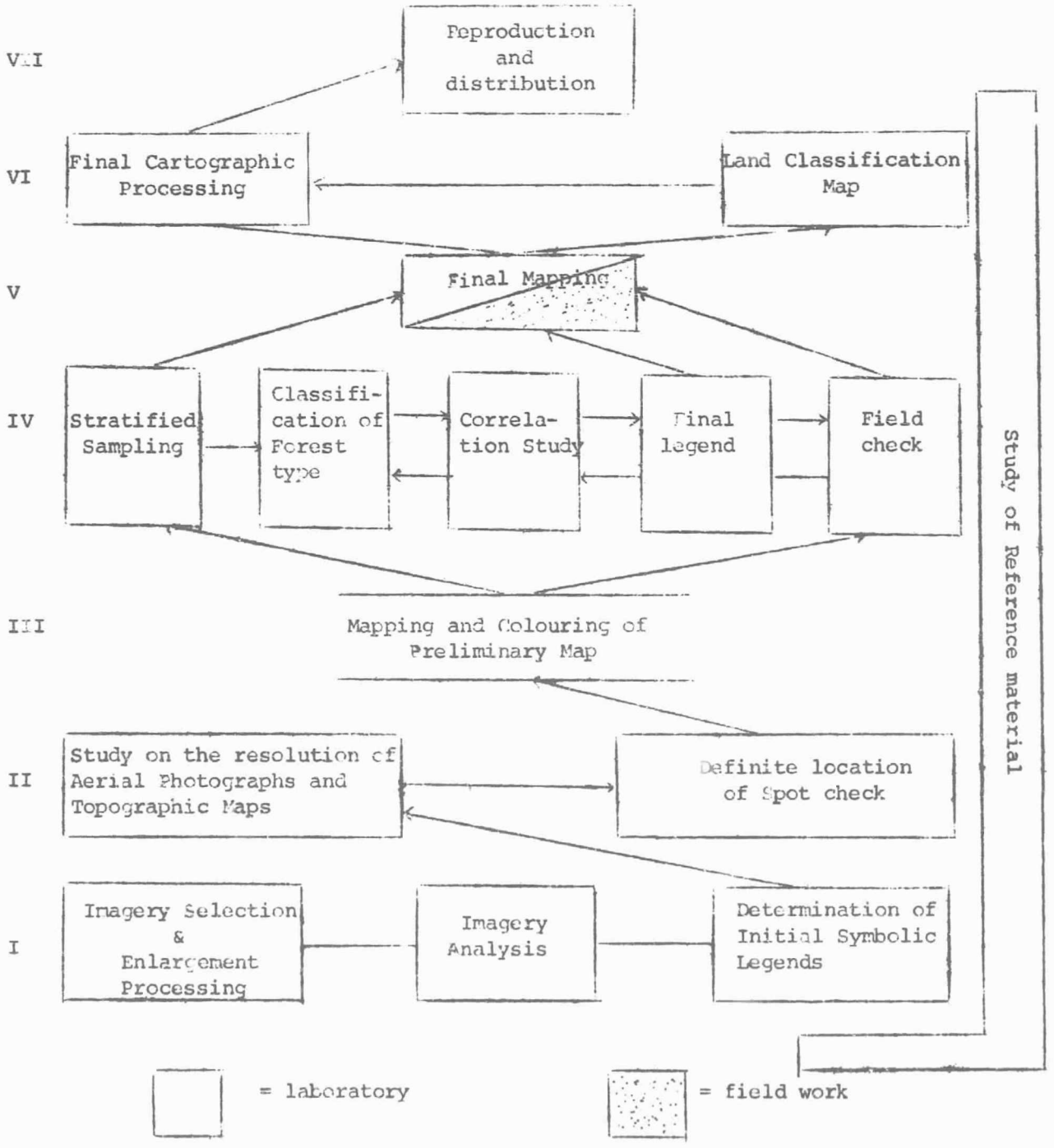


Figure 2: Scheme of Surveying and Mapping of Forest Using ERTS- Imagery.

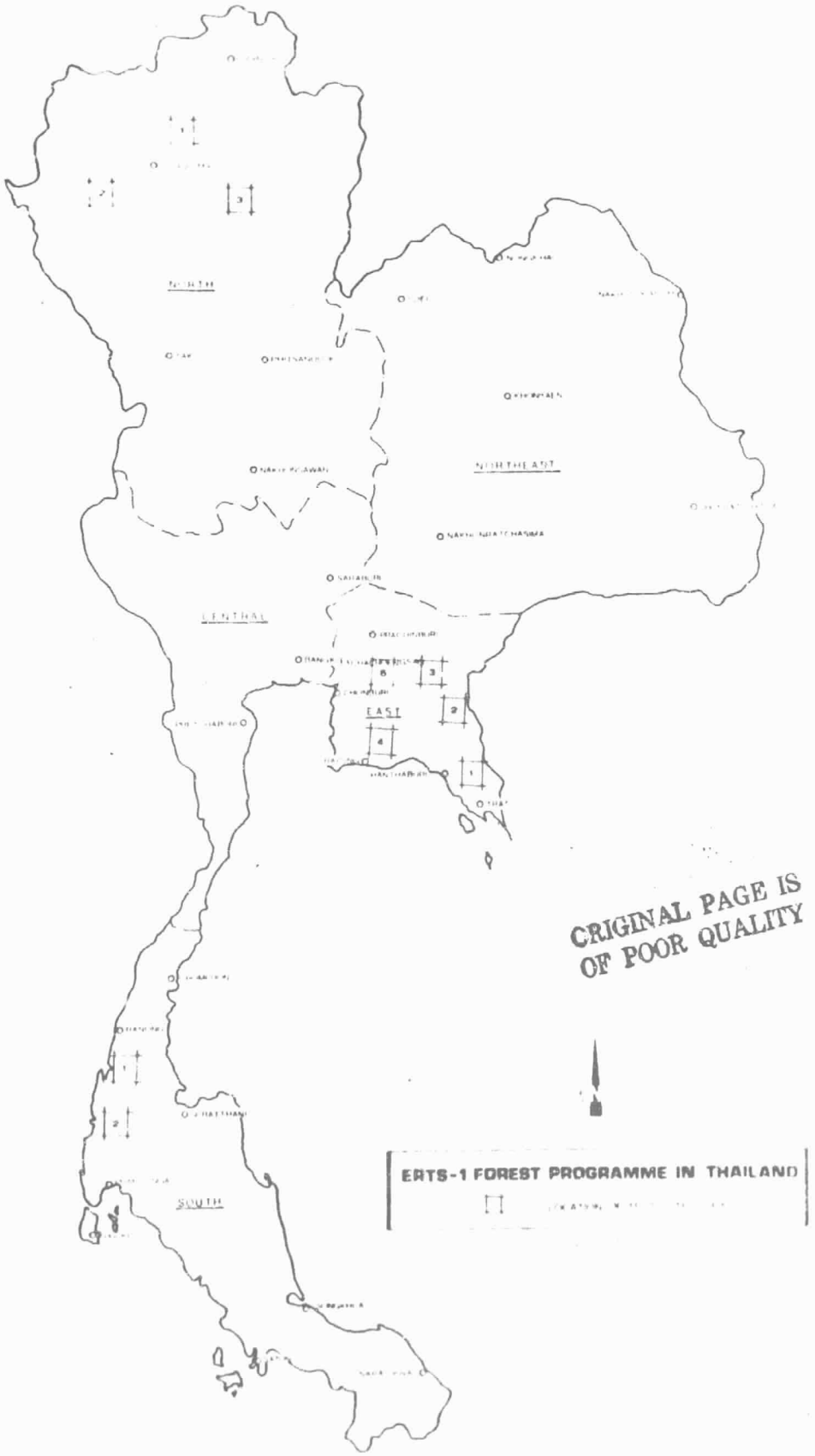


Figure 3 : Test Site Area for Ground Checks, Approximately 25 x 25 meters per Sampling Plot.

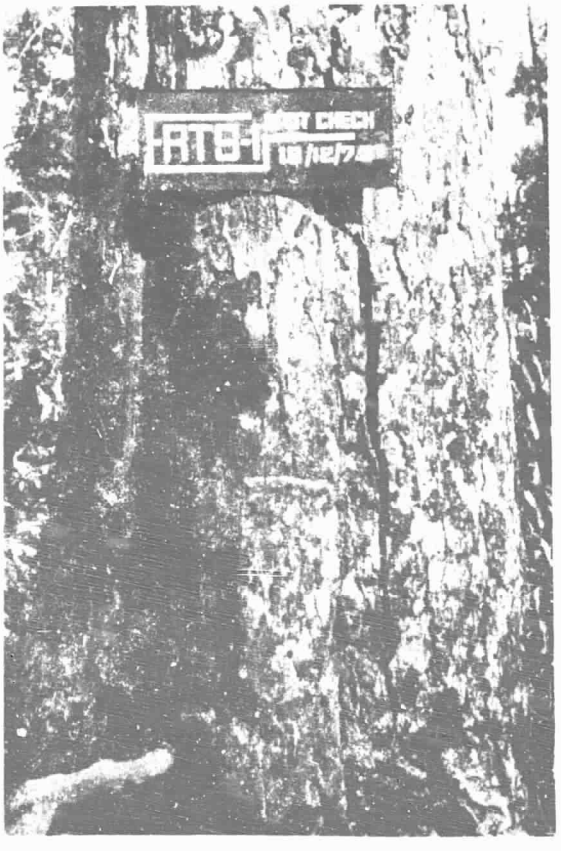


Figure 4 : Ground Truth Data

ERTS-1 PROGRAM

FOREST GROUND INFORMATION DATA SHEET.

SECTOR FORESTRY

ERTS-1 INFORMATION

LOCATION. AMPHOE PONG NAM RON CHANGWAT CHANTHABURI

CREDIT NO. E-1202-03014 MSS BAND 5 SCALE 1/500,000

DATE PHOTO 10/2/73 LAT 13°-07'-54" LONG 102°-19'-17"

FIELD PHOTOGRAPHY

APPROX. 2 KM. FROM THE SOUTH OF BAN SA TRON

FILM NO. COLOUR

TIME 13.20

DATE 26/6/73

LAND USE CATEGORY

VEGETATED AREA	01.	
CULTIVATED AREA	02.	
URBAN AREA	03.	
WATER AREA	04.	
OPEN LAND	05.	

SAMPLING PLOT No. 2/5

SIZE OF PLOT 50 X 50 M

ELEVATION. 150 M.

SLOPE. — /

ASPECT. —

LEVEL OF FOREST.	10	20	30	40	50	60	70	
FOREST DISTURBANCES.	1	2	3	4	5	6		
CROWN DENSITY.	1	2	3					
BASE CONDITION.	1	2	3	DECIDUOUS TREE				

DOMINANT TREE. Xylia kerrii Craib

HEIGHT. 30 M. ⊙ 1.20 M

MACRORELIEF. M

GROUND MOISTURE CONDITION. MEDIUM

No.	PROMINANT SPECIES.	NO OF TREE	AVE HEIGHT M.	No.	PROMINANT SPECIES.	NO OF TREE	AVE HEIGHT M.
1	Xylia kerrii Craib	8	34	7	Vitex peduncularis Wall.	2	8
2	Lagerstroemia floribunda Jack	10	25	8			
3	Cratoxylon pruniflorum Kurz.	2	32	9			
4	Dalbergia oliveri Gamble	4	35	10			
5	Croton oblongifolius Roxb.	1	20	11			
6	Litsea polyantha Juss.	2	32	12			

REMARK

SIGNATURE

DATE 26/6/73

5/3/73.

Figure 5 : Forest Ground Information Data Sheet

CODE

TYPE OF FOREST	CODE
Mixed Deciduous	10
Dry Dipterocarp	20
Tropical Evergreen	30
Pine Forest	40
Mangrove Forest	50
Bamboo Forest	60
Scrub	70

TYPE OF FOREST DISTURBANCES	CODE
Non-Disturbance	1
Cutting-Heavy	2
Cutting-Light	3
Fire Damage	4
Old clearing and Shifting cultivation	5
Infestation	6

MACRORELIEF CLASSES	CODE
Flat Land	M1
Undulating and Rolling Land	M2
Hilly Land	M3
Mountainous Land	M4

CROWN DENSITY	CODE
0 - 25 %	3
25 - 75 %	2
75 - 100 %	1

GROUND MOISTURE CONDITION	CODE
Wet	1
Medium	2
Dry	3
Very Dry	4

LEAF CONDITION (DECIDUOUS TREES)	CODE
Shedding	1
Spring	2
Flowering	3

Figure 6 : Code Labelled for Forest Ground Information Data Sheet.

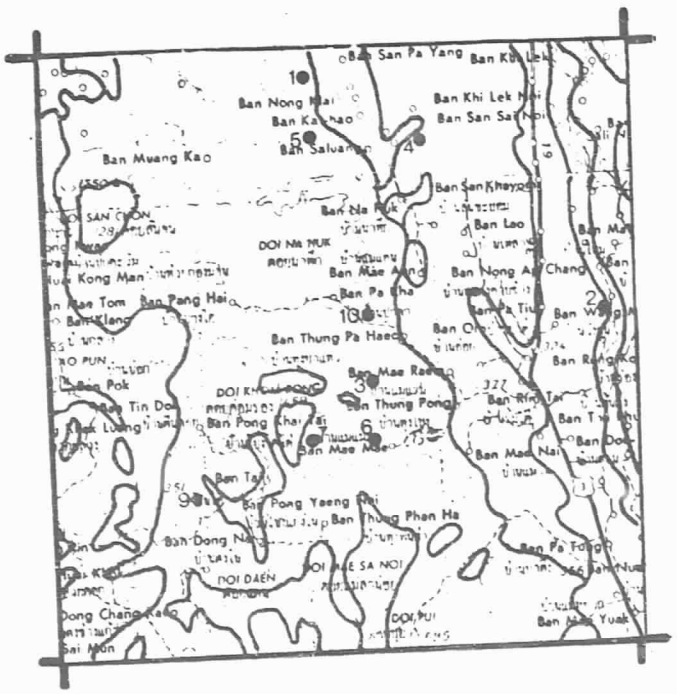
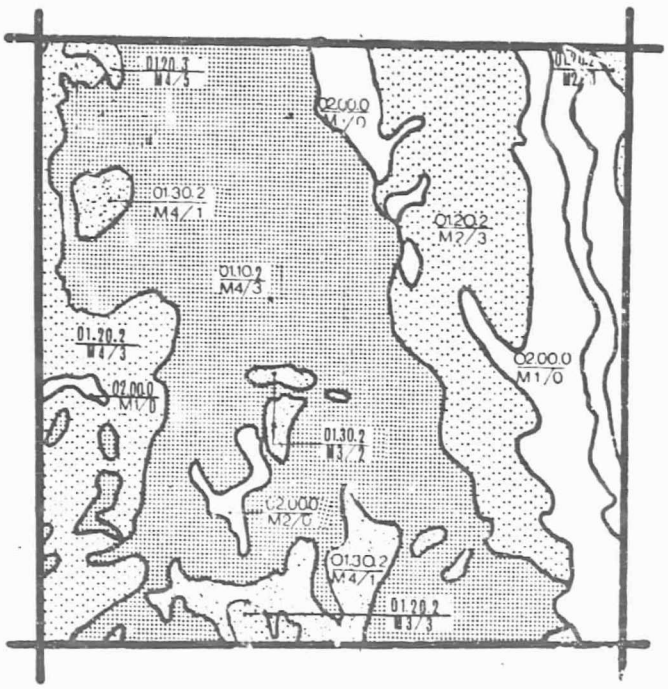


Fig. 7: Test Site Area 1. Amphoe Mae Rim, Changwat Chiangmai



LAND USE CATEGORY

- 01 Vegetated Area.
- 02 Cultivated Areas

TYPE OF FOREST

- 10 Mixed Deciduous
- 20 Dry Dipterocarp
- 30 Tropical Evergreen

CROWN DENSITY

- 1 75 - 100 %
- 2 25 - 75 %
- 3 0 - 25 %

MACRORELIEF CLASSES

- M1 Flat Land
- M2 Undulating and Rolling Land
- M3 Hilly Land
- M4 Mountainous Land

TYPE OF FOREST DISTURBANCES

- 1 Non Disturbances
- 2 Cutting Heavy
- 3 Cutting Light
- 4 Fire Damage
- 5 Old Clearing and Shifting Cultivation

Fig. 8: Test Site Area 1. Amphoe Mae Rim, Changwat Chiangmai.

V. Results

1. The results of the study provide the information on the existing forest area of the whole country in a reasonably short period of time. Forested and non-forested areas can be distinguished clearly (See Forest Map of Thailand). According to the aerial survey and ground checks in 1961, forest areas were reported to be about 55% of the whole country. The investigation using ERTS-1 imagery showed that the forest area has been extensively depleted and decreased to approximately 38.6% by 1973. (Table 1 to 6)

Such benefits derived from ERTS-1 imagery and future earth resources satellites will enable the Royal Forest Department to set up more intelligent policies and plans for forest conservation, protection, determination of watershed areas, land use policy, and selection of reforestation areas.

2. The interpretation of ERTS-1 imagery is based on the Multi-Spectral Scanner (MSS) data which produces four synchronous images, each at a different wave band. Each band is suitable for particular purposes. The following evaluation is to give a general impression of the suitability for specific purposes of the four bands.

Band 4 (Green), 0.5 to 0.6 micrometers, sometimes qualitatively discriminates the depth and/or turbidity of standing bodies of water.

Band 5 (Red), 0.6 to 0.7 micrometers, is best for showing topographic, forest area, and cultural features, such as drainage patterns, roads and towns.

Band 6 (Lower infrared), 0.7 to 0.8 micrometers, shows the best tonal contrasts that reflect various land use practices. It also gives high land/water contrast.

Band 7 (Infrared), 0.8 to 1.1 micrometers, is best for land and water discrimination.

Thus, for general display purposes, a scene is best presented by four photos. If only one image is to be used, band 5 will usually be the best choice, especially in forest investigation. If a second band is needed, Band 7 should be selected.

3. Because coverage by ERTS-1 is repetitive (every 18 days - the temporal aspect), it is possible to follow certain trends (temporal changes) by studying consecutive images. For instance, the changes in forest land use derived from shifting cultivation can be traced.

VI. Future Plan

During the current fiscal year, which started in October 1973, continuing checks and studies will be carried out throughout the country except in the eastern region. Therefore, our next phase emphasizes finding the location of existing forest areas and details of the changing situation. The expenses

of these activities will be paid by the Thai government but the equipments will be supplied under the cooperation of the Royal Forest Department, the Applied Scientific Research Corporation of Thailand and the National Research Council and US Operation Mission to Thailand. Thereafter, intensive research will be pursued with the objective of finding the optimum techniques for ERTS image interpretation for forest area determination and forest typing.

VII. Conclusions and Recommendations

From the research on ERTS-1 imagery (Black and White), a map showing results of the interpretation in forest aspects at a scale 1:500,000 has been produced. It is clearly evident that remote sensing will be an increasingly useful tool in forestry. It can contribute much knowledge to the forester in exploring, developing and managing forests and related wildlands. The characteristics of forest can be recognized by combinations of texture and tone contrast. Because of the small scale of the images and the fact that the present application is in a preliminary stage, the utilization is limited in so far as the forest cover type identification is concerned, but the forested and non-forested areas can be separated completely by the use of MSS band 5. The existing forest areas can be detected and changing conditions due to man-made or natural disturbances can be known by comparing imagery of two different time periods.

Practical and economic benefits are very substantial. Given cloud free ERTS MSS images, a whole country survey of remaining forest assets can be accomplished in one year. It had not been possible in the past to make a complete survey more frequently than every 10 years because of the time required for analysis of thousands of aerial photos and the cost involved invalued in acquiring up-to-date aerial photography and considerable manpower.

Continuous coverage of the quality images received in 1972-73 would permit annual up-dating of forest area maps with the following advantages: substantially reduced survey costs and greatly reduced time between comprehensive surveys in planning of national land use policies, providing more intelligent planning and monitoring of reforestation and watershed protection programs, etc.

The management practices can not be considered to be Multiple-Use in Thailand because they need to be practiced for better skill and technical knowledge in applying forest practices, as well as emphasizing all benefits from the forest.

From this study, recommendations for forest management in Thailand are made as follows:

1. Increase protection from unauthorized timber cutting by using ERTS imagery.

2. Improve the protection of game and development programs.

3. Increase and develop more recreation areas.

4. Increase the intensity of timber management.

5. Increase and develop more watershed management by using ERTS imagery band 5 and 7.

6. Increase the detection of shifting cultivation by using enlarged diazochrome or ERTS imagery.

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Table 1: Comparison of forest land between Land Use Map, Aerial photos, and ERTS-1 imagery in Thailand

No.	Region	Total Area L.C.S.	ERTS	Area Changed		% *	A.P.S.	ERTS	Area Changed		% *	% of forest in Region
				Km^2	%				Km^2	%		
1	North	171,775	126,821	95,842	30,979	24.4	4.9	116,275	95,842	20,433	17.6	2.2	55.80
2	East	36,394	18,174	15,036	3,138	17.3	1.4	21.163	15,036	6,127	29.0	2.9	41.31
3	Northeast	174,407	62,972	47,466	15,506	24.6	3.7	70,904	47,466	23,438	33.1	3.2	27.22
4	Central	67,189	33,708	23,970	9,738	28.9	7.6	35,660.5	23,970	11,690.5	32.8	3.8	35.68
5	South	70,188	27,282	18,435	8,846	32.4	17.7	29,626	18,435	11,191	37.8	3.8	26.27
	Total	519,953	268,956	200,749	68,207	25.4	7.1	273,628.5	200,749	72,879.5	26.6	3.2	38.61

L.C.S. - Forest Land from Land Classification Survey in 1961, Land Development Department

A.P.S. - Forest Land from Aerial Photo Survey in 1961, Royal Forest Department

% * - Percent decreased per year

ERTS - ERTS-imagery in 1972-1973, some ground check in 1974

Source: From Forest Management Division, Royal Forest Department January 1975

Table 2: Comparison of forest land between Land Use Map, Aerial Photo and ERTS-1 imagery of the North

No.	Changwat	Total Area (Km^2)	L.C.S. and ERTS in 1973					% *	A.P.S.	ERTS	Area Changed		% *
			L.C.S.		ERTS	Area Changed							
			year	Km^2		Km^2	%				Km^2	%	
1	Chiangrai	18,803	1970	12,405	9,020	3,385	27.3	6.8	9,493	9,020	473	5.0	0.4
2	Chiangmai	22,993	1966	19,768	15,690	4,078	20.6	2.9	16,750	15,690	1,060	6.3	0.5
3	Lamphun	4,407	1966	3,345	3,440	+95	-	-	3,466	3,440	26	0.8	0.1
4	Maehongsorn	13,222	1966	12,001	9,152	2,849	23.7	3.4	10,490	9,152	1,338	12.8	1.1
5	Lampang	12,518	1970	10,135	8,572	1,563	15.4	3.9	9,448	8,572	876	9.3	0.8
6	Naan	11,694	1964	10,461	7,804	2,657	25.4	2.8	8,162	7,804	358	4.4	0.4
7	Phrae	5,847	1964	5,044	4,328	716	14.2	1.6	3,853	4,328	+475	-	-
8	Utaradit	8,736	1964	6,843	5,704	1,139	16.6	1.8	6,052	5,704	348	5.8	0.5
9	Phetchabun	11,166	1966	8,735	3,680	5,055	57.9	8.3	8,928	3,680	5,248	58.8	4.9
10	Phitsanulok	9,659	1966	5,940	2,740	3,200	53.9	7.7	5,914	2,740	3,174	53.7	4.5
11	Sukhothai	6,481	1965	3,787	3,616	171	4.5	0.6	4,357	3,616	741	17.0	1.4
12	Kamphaengphetch	8,954	1966	6,163	3,500	2,663	43.2	6.2	6,737	3,500	3,237	48.0	4.0
13	Phijit	4,530	1966	547	-	-547	100	14.3	902	-	-902	100	8.3
14	Nakhon Sawan	9,677	1964	2,291	1,248	1,043	45.5	5.1	2,951	1,248	1,703	57.7	4.8
15	Uthaithani	7,479	1970	5,040	4,536	504	10.0	2.5	4,899	4,536	363	7.4	0.6
16	Tak	15,609	-	14,316	12,812	1,504	10.5	-	13,873	12,812	1,061	7.6	0.6
	Total	171,775		126,821	95,842	30,979	24.4	4.9	116,275	95,842	20,433	17.6	2.2

% * Percent decreased per year

Source: From Forest Management Division, Royal Forest Department, January 1975.

Table 3: Comparison of forest land between Land Use Map, Aerial Photo and ERTS-1 imagery of the Central.

No.	Changwat	Total Area (KM^2)	L.C.S. and ERTS in 1973					% *	A.P.S. 1961 and ERTS 1973				% *
			L.C.S.		ERTS	Area Changed			.P.S.	ERTS	Area Changed		
			Year	KM^2		KM^2	%				KM^2	%	
1	Kanchanaburi	19,486	1968	17,387	13,549	3,838	22.1	4.4	17,793	13,549	4,244	23.9	2.0
2	Chainat	2,636	1968	156	85	71	45.5	9.1	0.5	85	+84.5	-	-
3	Lopburi	6,588	1961	2,046	529	1,517	74.1	6.5	2,105	529	1,576	74.9	6.2
4	Saraburi	2,963	1963	914	289	625	68.4	6.8	604	289	315	52.2	4.4
5	Ayuthaya	2,480	-	-	-	-	-	-	-	-	-	-	-
6	Pathumthani	1,497	-	-	-	-	-	-	-	-	-	-	-
7	Bangkok	1,549	-	-	-	-	-	-	-	-	-	-	-
8	Ratburi	5,120	1959	3,327	1,876	1,451	43.6	3.1	3,368	1,876	1,492	44.3	3.7
9	Phetburi	6,357	1971	4,313	3,636	677	15.7	7.9	4,731	3,636	1,095	23.1	1.9
10	Prachuap	6,373	1970	4,218	3,198	1,020	24.2	8.1	5,038	3,198	1,840	36.5	3.0
11	Suphanburi	5,339	1970	1,347	748	599	44.5	14.8	2,021	748	1,273	63.0	5.3
12	Samutsakhon	840	-	-	-	-	-	-	-	-	-	-	-
13	Samutsongkram	403	-	-	60	+60	-	-	-	60	+60	-	-
14	Samutprakhan	934	-	-	-	-	-	-	-	-	-	-	-
15	Nonthaburi	623	-	-	-	-	-	-	-	-	-	-	-
16	Nakhonpatom	2,178	-	-	-	-	-	-	-	-	-	-	-
17	Angthong	981	-	-	-	-	-	-	-	-	-	-	-
18	Singburi	842	-	-	-	-	-	-	-	-	-	-	-
	Total	67,189	-	33,708	23,970	9,738	28.88	7.6	35,660.5	23,970	11,690.5	33.78	3.8

% * Percent decreased per year.

Source: From Forest Management Division, Royal Forest Department, January 1975.

Table 4: Comparison of forest land between Land Use Map, Aerial Photo and ERTS-1 imagery of the East.

No.	Changwat	Total Area (KM^2)	L.C.S. and ERTS in 1973					% *	A.P.S. 1961 and ERTS 1973				% *
			L.C.S.		ERTS	Area Changed			A.P.S.	ERTS	Area Changed		
			Year	KM^2		KM^2	%				KM^2	%	
1	Chonburi	4,485	1961	1,336	1,020	316	23.7	2.0	2,145	1,020	1,125	52.4	4.4
2	Rayong	3,307	1966	1,183	988	195	16.5	2.4	1,867	988	879	47.1	3.9
3	Chanthaburi	6,052	1964	3,827	3,167	660	17.2	1.9	3,953	3,167	786	19.9	1.7
4	Traad	2,919	1964	1,130	1,060	70	6.2	0.7	1,784	1,060	724	40.6	3.4
5	Chachoengsao	5,422	1964	2,705	2,624	81	3.0	0.3	2,870	2,624	246	8.6	0.7
6	Prachinburi	11,795	1963	7,407	5,592	1,815	24.5	2.5	7,409	5,592	1,817	24.5	2.0
7	Nakorn Nayok	2,414	1964	586	585	1	0.2	0.0	1,135	585	550	48.5	4.0
	Total	36,394		18,174	15,036	3,138	17.3	1.4	21,163	15,036	6,127	29.0	2.9

% * Percent decreased per year.

Source: From Forest Management Division, Royal Forest Department, January 1975.

Table 5: Comparison of forest land between Land Use Map, Aerial Photo and ERTS-1 Imagery of the Northeast.

No.	Changwat	Total Area (KM^2)	L.C.S. and ERTS in 1973					% *	A.P.S. 1961 and ERTS 1973				% *
			L.C.S.		ERTS	Area Changed			A.P.S.	ERTS	Area Changed		
			Year	KM^2		KM^2	%				KM^2	%	
1	Kalasin	7,650	1965	2,135	1,989	146	6.8	0.9	4,410	1,989	2,421	54.9	4.6
2	Khonkaen	13,404	1965	3,175	2,236	939	29.6	3.7	3,105	2,236	869	28.0	2.3
3	Chaiyaphum	10,788	1963	7,132	6,611	521	7.3	0.7	8,344	6,611	1,733	20.8	1.7
4	Nongkai	7,223	1963	3,441	2,767	674	19.6	2.0	4,373	2,767	1,606	36.7	3.1
5	Nakhon Phanom	9,749	1963	4 256	4,511	4255	-	-	5,125	4,511	614	12.0	1.0
6	Mahasarakham	5,760	1963	454	324	130	28.6	2.9	619	324	295	47.7	4.0
7	Udonthani	16,605	1966	8,001	2,627	5,374	67.2	9.6	6,954	2,627	4,327	62.2	5.2
8	Nakhon Rajsima	19,590	1963	9,382	5,713	3,669	39.1	3.9	11,378	5,713	5,665	49.8	4.2
9	Burirum	11,323	1963	3,943	2,566	1,377	34.9	3.5	3,353	2,566	787	23.5	2.0
10	Roi-et	7,856	1963	933	1,013	480	-	-	1,945	1,013	932	48.0	4.0
11	Loei	10,936	Clouded, no ground truth checking					-	-	-	-	-	-
12	Surin	8,784	1963	2,818	1,742	1,076	38.2	3.8	2,895	1,742	1,153	39.8	3.3
13	Srisakate	9,814	1963	4,681	1,937	2,744	58.6	5.9	2,815	1,937	878	31.2	2.6
14	Sakonnakhon	9,539	1963	3,720	4,399	+679	-	-	8,288	4,399	3,889	46.9	3.9
15	Ubonrajthani	21,335	1963	8,901	9,031	+130	-	-	7,300	9,031	+1,731	-	-
16	Yasothon	4,451	Clouded, no ground truth checking										
	Total	174,407		62,972	47,466	15,506	24.6	3.7	70,904	47,466	23,438	33.05	3.2

% * Percent decreased per year

Source: From Forest Management Division, Royal Forest Department, January 1975.

Table 6: Comparison of forest land between Land Use Map, Aerial Photo and ERTS-1 Imagery of the South.

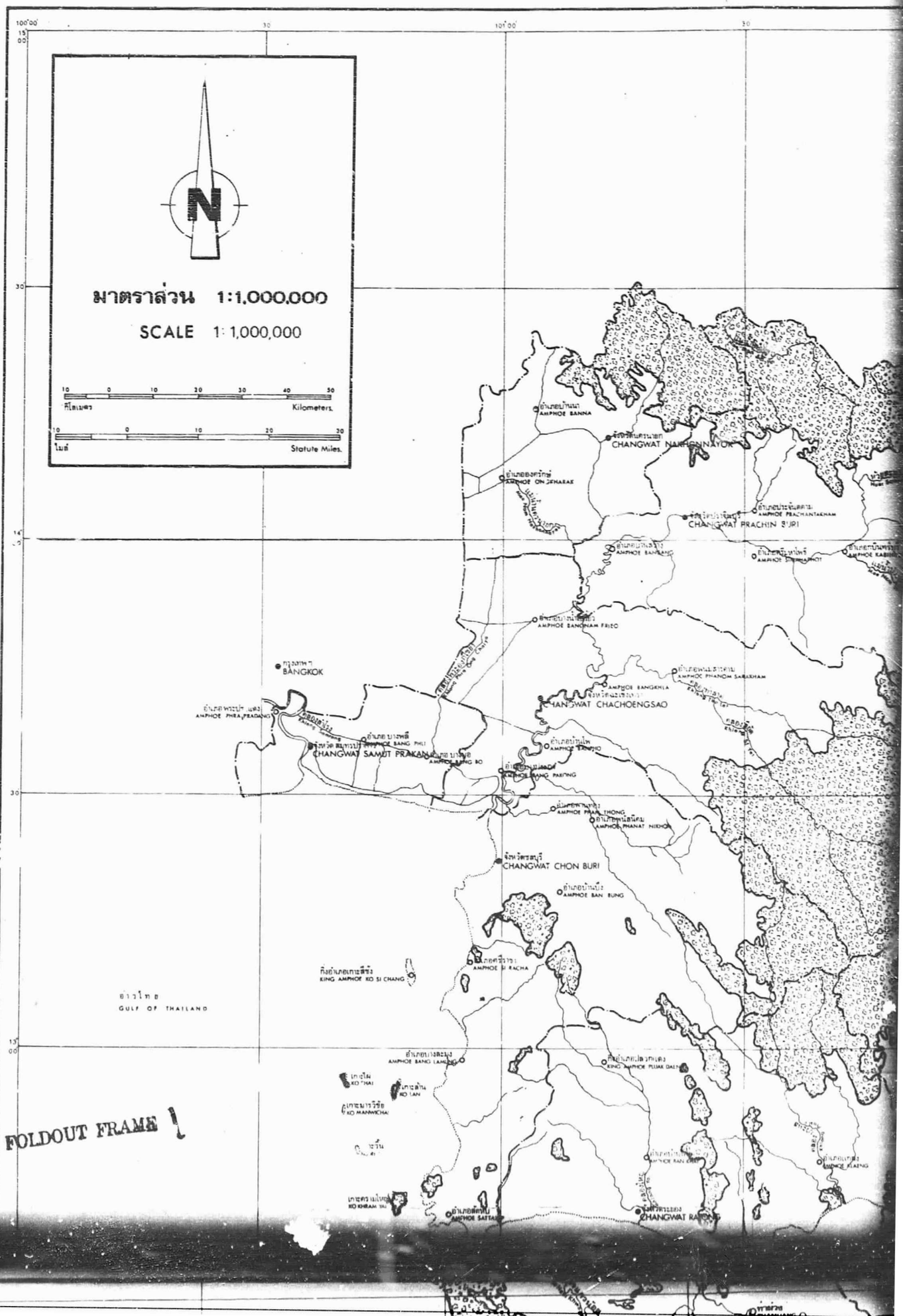
No.	Changwat	Total Area (KM^2)	L.C.S. and ERTS in 1973					% *	A.P.S. 1961 and ERTS 1973				% *
			L.C.S.		ERTS	Area Changed			A.P.S.	ERTS	Area Changed		
			Year	KM^2		KM^2	%				KM^2	%	
1	Chumphorn	5,746	1970	3,676	2,702	974	26.5	8.8	4,144	2,702	1,442	34.8	2.9
2	Ranong	3,426	1974	2,628	2,526	102	3.9	3.9	3,008	2,526	482	16.0	1.3
3	Phang-nga	4,100	1961	2,212	1,650	562	25.4	2.1	3,005	1,650	1,355	45.1	3.8
4	Suratthani	12,811	1961	7,691	6,202	1,489	19.4	1.6	8,194	6,202	1,992	24.3	2.0
5	Phuket	801	1961	611	137	474	77.6	6.5	273	137	136	49.8	4.2
6	Krabi	4,624	1972	3,082	921	2,161	70.1	70.1	2,769	921	1,848	66.7	5.6
7	Nakhon Sritamarat	10,169	1973	3,857	1,790	2,067	53.6	53.6	3,368	1,790	1,578	46.9	3.9
8	Trang	4,944	1961	2,212	1,370	842	38.1	3.2	2,449	1,370	1,079	44.1	3.7
9	Phattalung	3,269	1970	-	-	-	-	-	-	-	-	-	-
10	Satoon	2,669	1971	1,159	1,052	107	9.2	4.6	2,128	1,052	1,076	50.6	4.2
11	Songkhla	6,672	1972	-	-	-	-	-	-	-	-	-	-
12	Pattani	2,013	1971	153	85	68	44.4	22.2	288	85	203	70.5	5.9
13	Yala	4,716	-	-	-	-	-	-	-	-	-	-	-
14	Narathiwat	4,228	-	-	-	-	-	-	-	-	-	-	-
	Total	70,188		27,281	18,435	8,846	32.42	17.7	29,626	18,435	11,191	37.77	3.8

% * Percent decreased per year

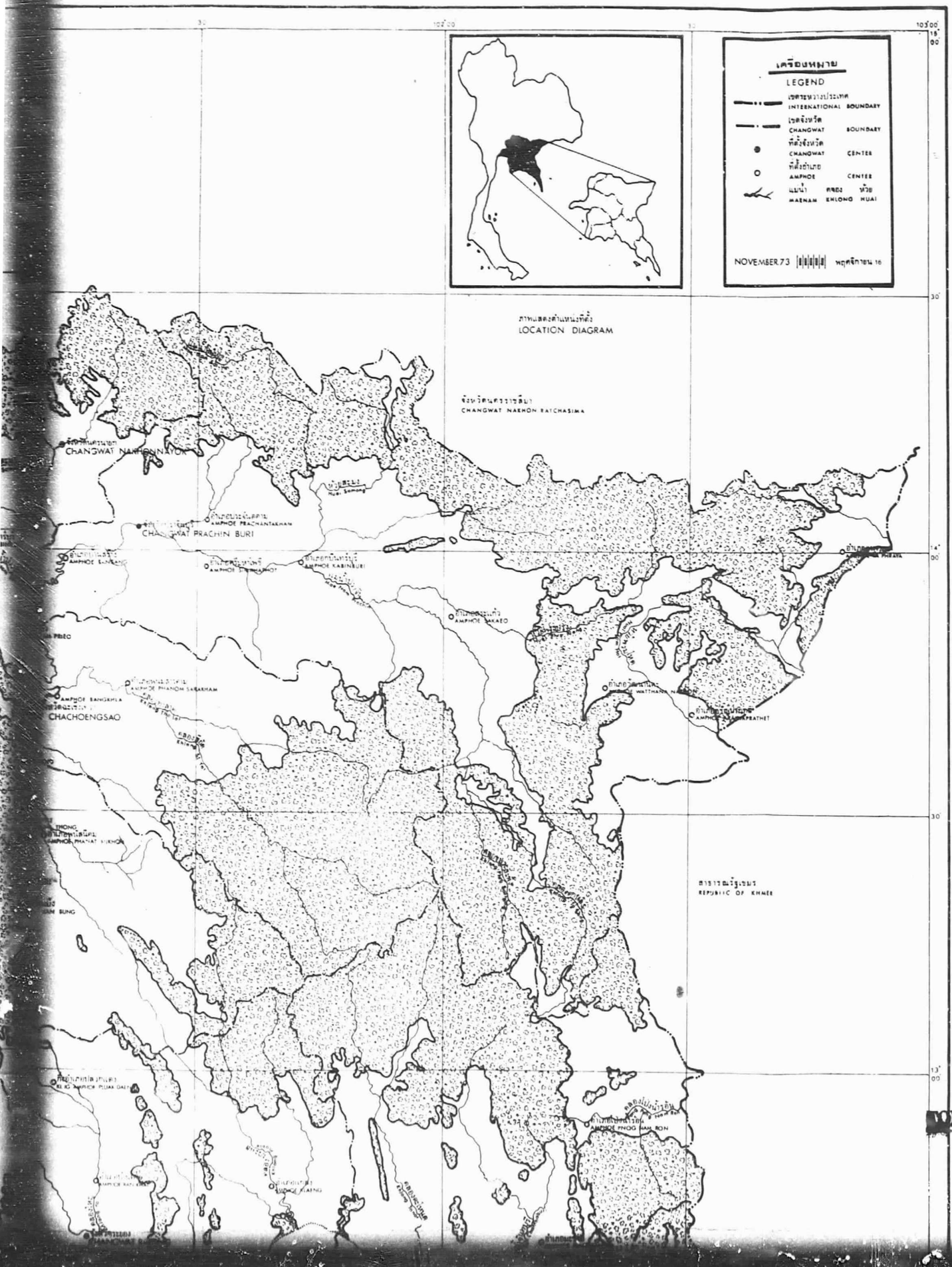
Source: From Forest Management Division, Royal Forest Department, January 1975.

X. Forest Map of Thailand

37



FOLDOUT FRAME 1



FOLDOUT FRAME 1

ภาคตะวันออก ประเทศไทย

EAST THAILAND

แผนที่ป่าไม้

FOREST MAP

พื้นที่ป่าไม้
FOREST AREA

พื้นที่ไม่ใช่ป่าไม้
NON-FOREST AREA

บันทึกสำหรับผู้ใช้

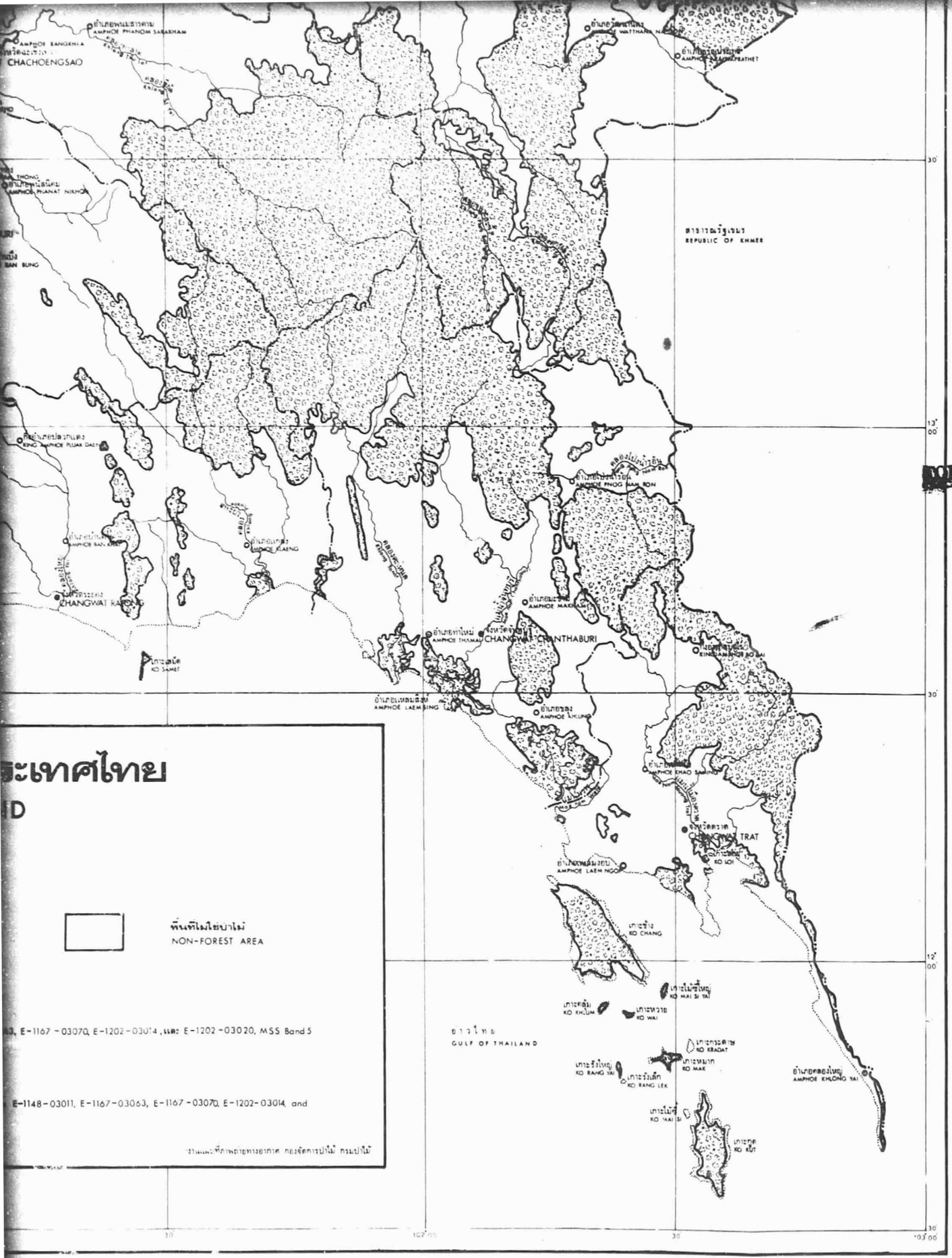
รายละเอียดบนแผนที่นี้อาศัยภาพถ่ายจากดาวเทียม ERTS-1 Frame E-1148-03011, E-1167-03063, E-1167-03070, E-1202-03014, และ E-1202-03020, MSS Band
ประกอบกับการตรวจสอบทางภาคพื้นดินเมื่อปี 2516

NOTE TO USERS:

The information on this map is based on the application of the recognition of ERTS-1, frame E-1148-03011, E-1167-03063, E-1167-03070, E-1202-03014, and E-1202-03020 imageries, MSS band 5 with some ground checks, 1973.

AERIAL PHOTOGRAPHY AND MAPPING SECTION, FOREST MANAGEMENT DIVISION, ROYAL FOREST DEPARTMENT, BANGKOK, THAILAND.

FOLDOUT FRAME 3



ะเทศไทย

ID

พื้นที่ไม่ใช่ป่าไม่
NON-FOREST AREA

3, E-1167-03070, E-1202-03014, และ E-1202-03020, MSS Band 5

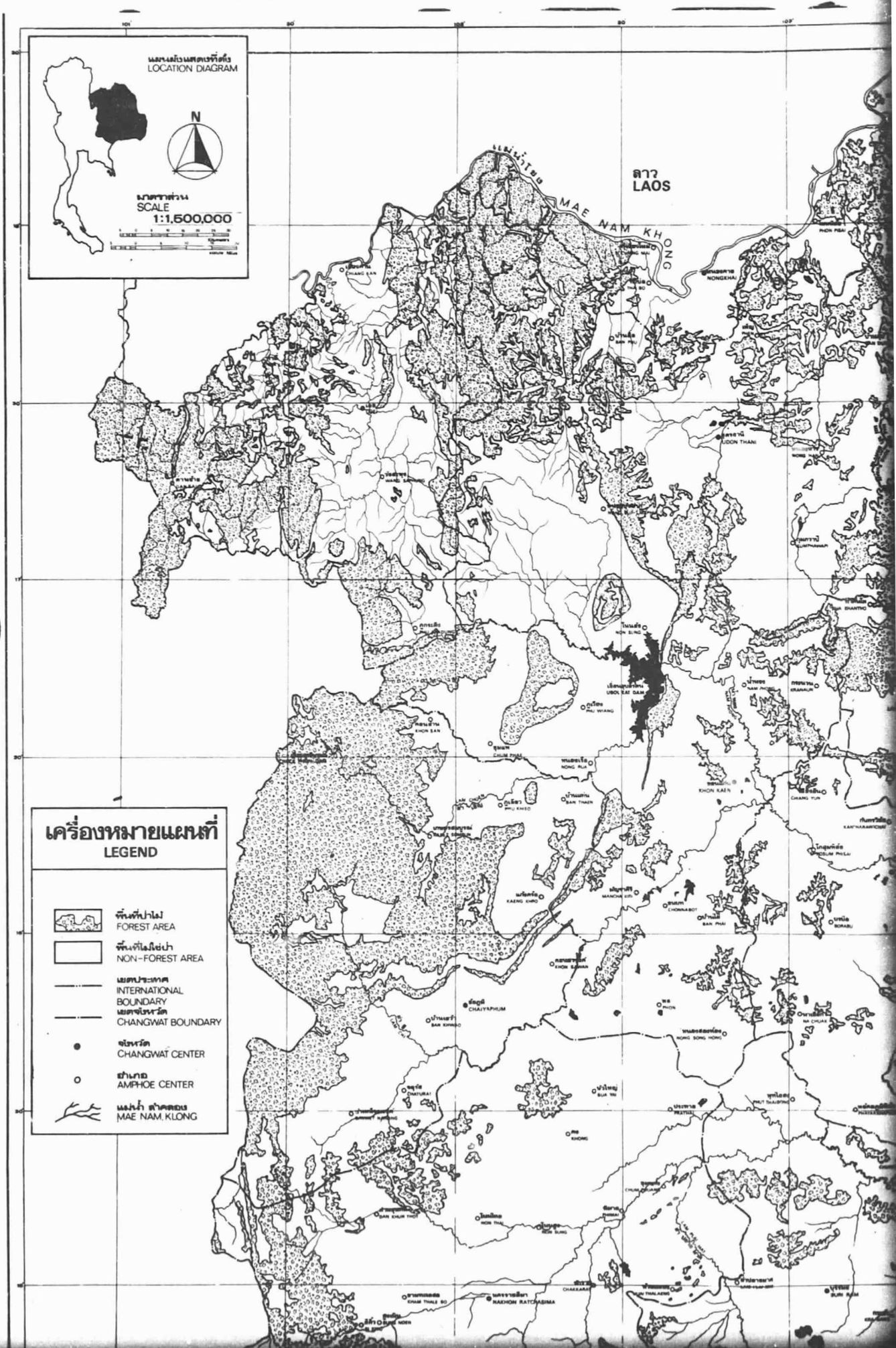
E-1148-03011, E-1167-03063, E-1167-03070, E-1202-03014, and

FOLDOUT FRAME 2

FOLDOUT FRAME 4

38

FOLDOUT FRAME

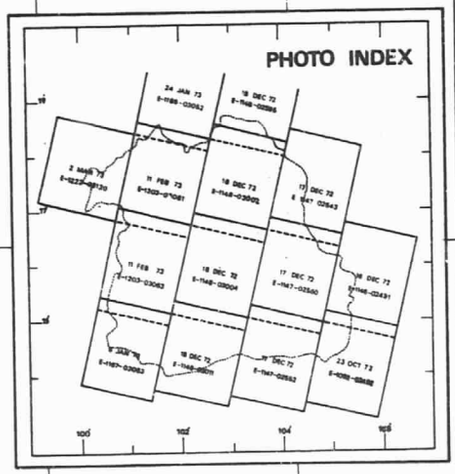


38a

แผนที่ป่าไม้ภาคตะวันออกเฉียงเหนือ
FOREST MAP OF NORTHEAST THAILAND

งานแผนที่ภาพถ่ายทางอากาศ
กองจัดการป่าไม้ กรมป่าไม้

AERIAL PHOTOGRAPHY AND MAPPING SECTION
FOREST MANAGEMENT DIVISION
ROYAL FOREST DEPARTMENT
จากภาพถ่ายดาวเทียม ERTS–1

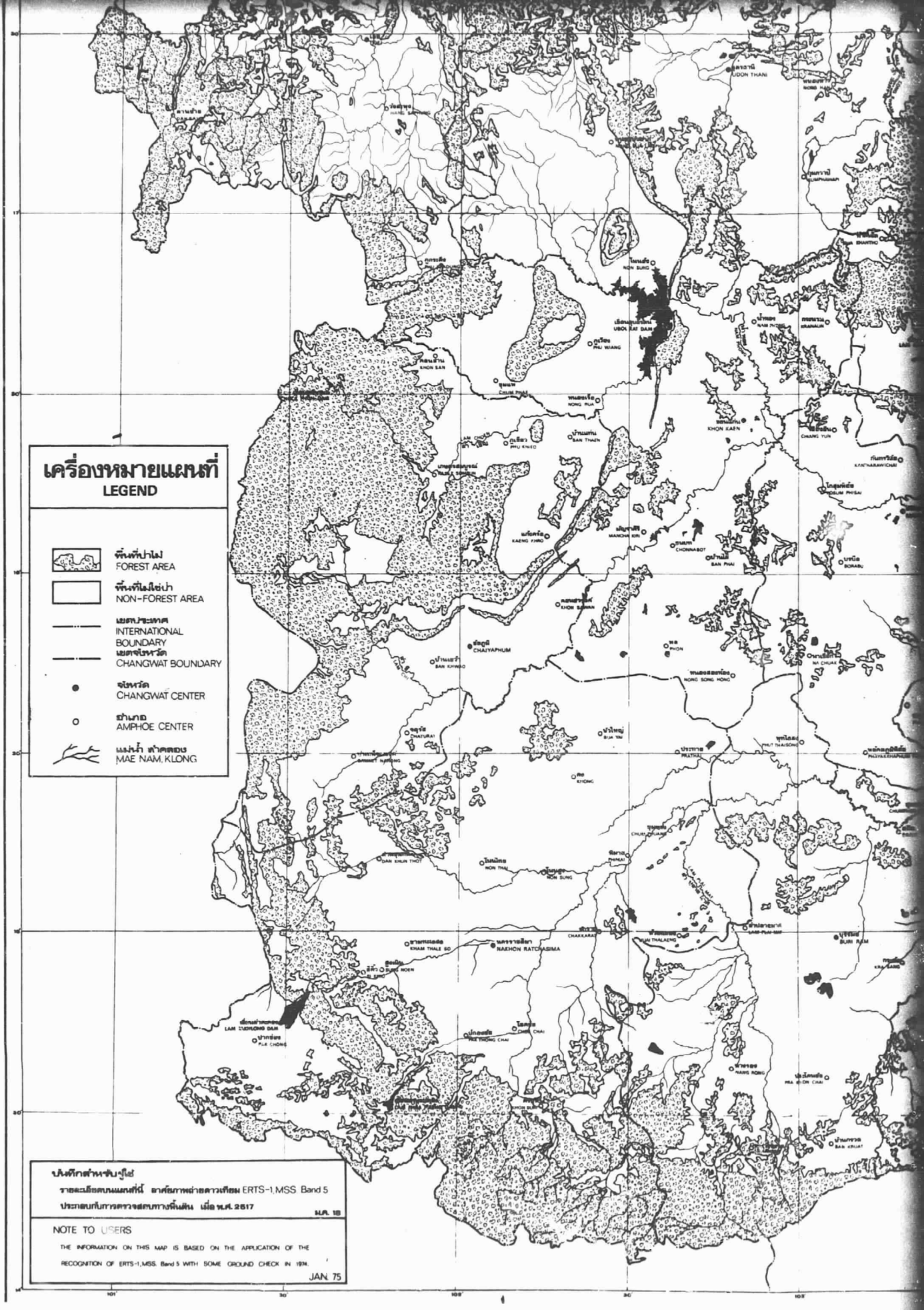


แม่น้ำโขง
MAE NAM KHONG

ลาว
LAOS

FOLDOUT FRAME 2

FOLDOUT FRAME 1



บันทึกสำหรับผู้ใช้

รายละเอียดบนแผนที่นี้ ได้ศึกษาจากภาพถ่ายดาวเทียม ERTS-1, MSS Band 5 ประกอบกับการตรวจสอบทางพื้นดิน เมื่อ พ.ศ. 2517

พ.ศ. 18

NOTE TO USERS

THE INFORMATION ON THIS MAP IS BASED ON THE APPLICATION OF THE RECOGNITION OF ERTS-1, MSS. Band 5 WITH SOME GROUND CHECK IN 1974.

JAN. 75

FOLDOUT FRAME 3

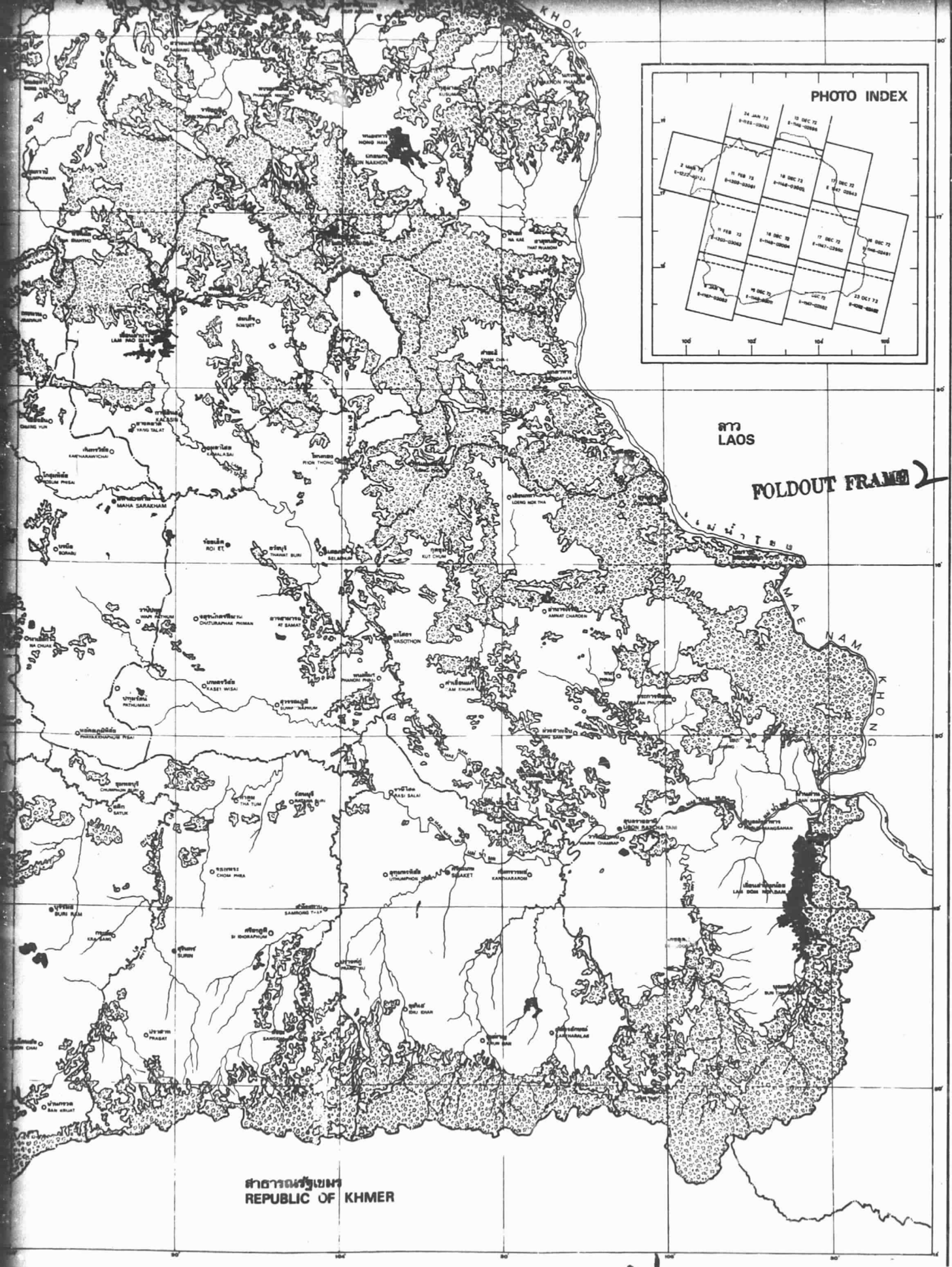
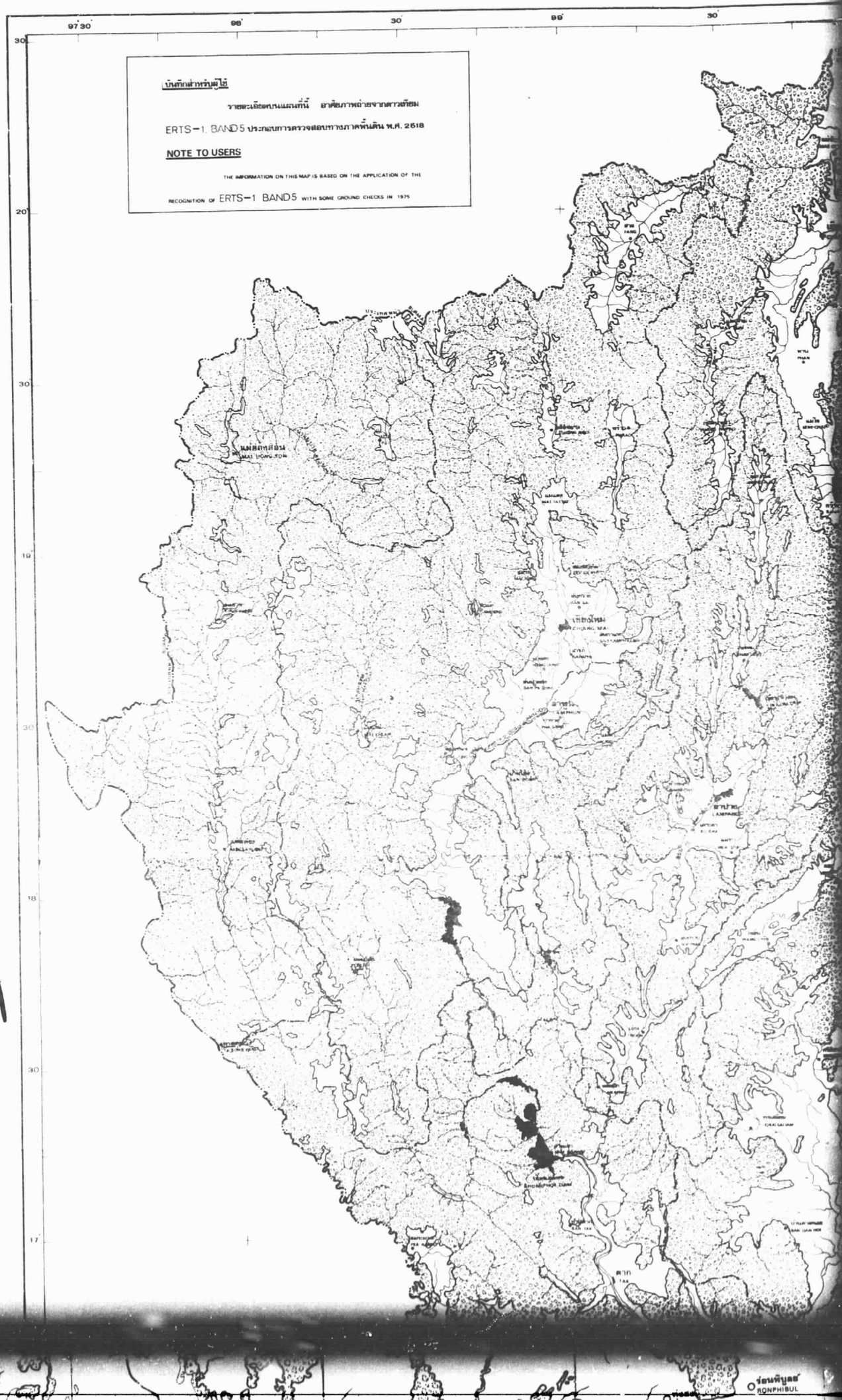


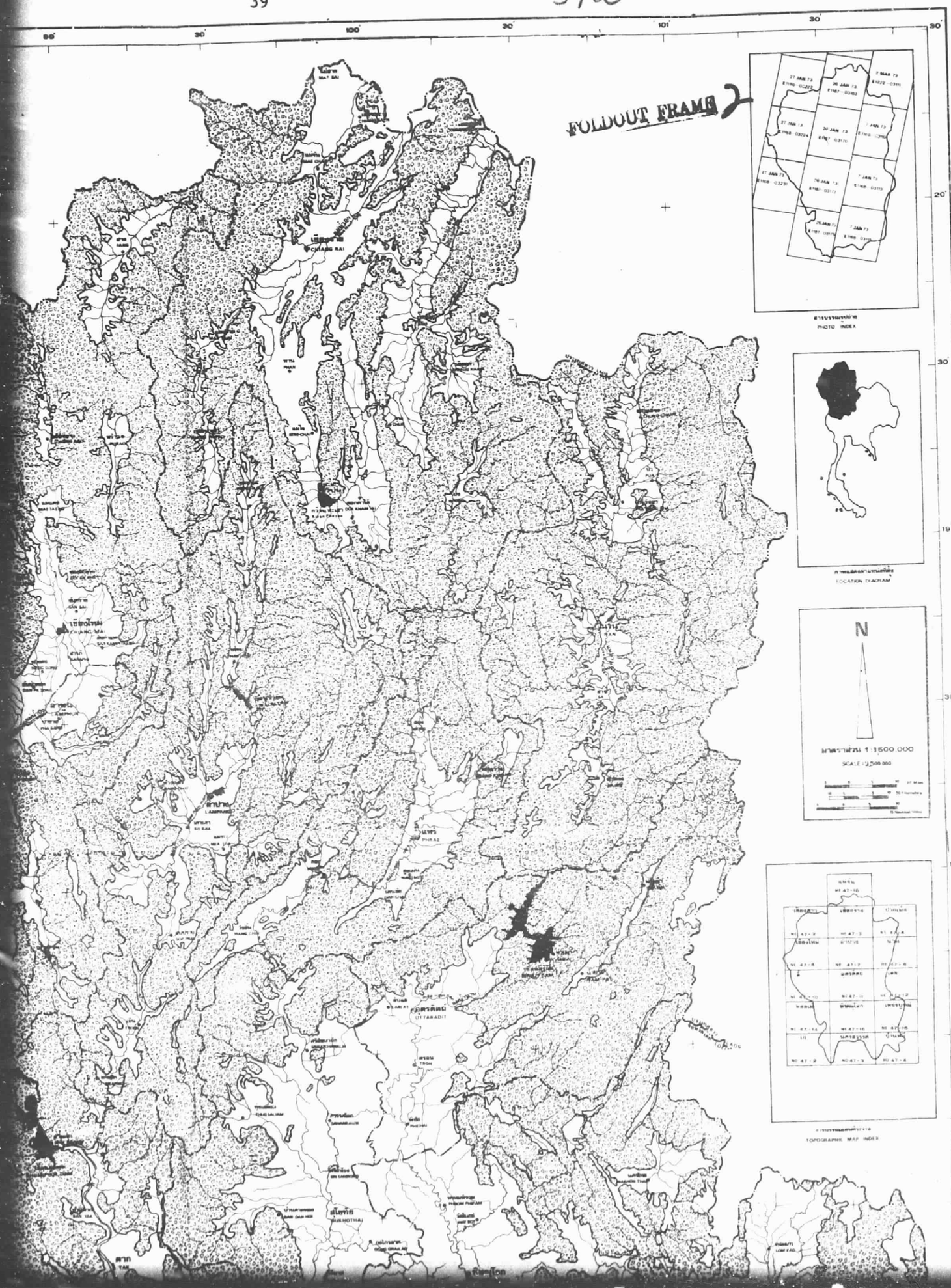
PHOTO INDEX
ลาว
LAOS
FOLDOUT FRAME 2
MAE NAM KHONG
สาธารณรัฐเขมร
REPUBLIC OF KHMER
FOLDOUT FRAME 2

39

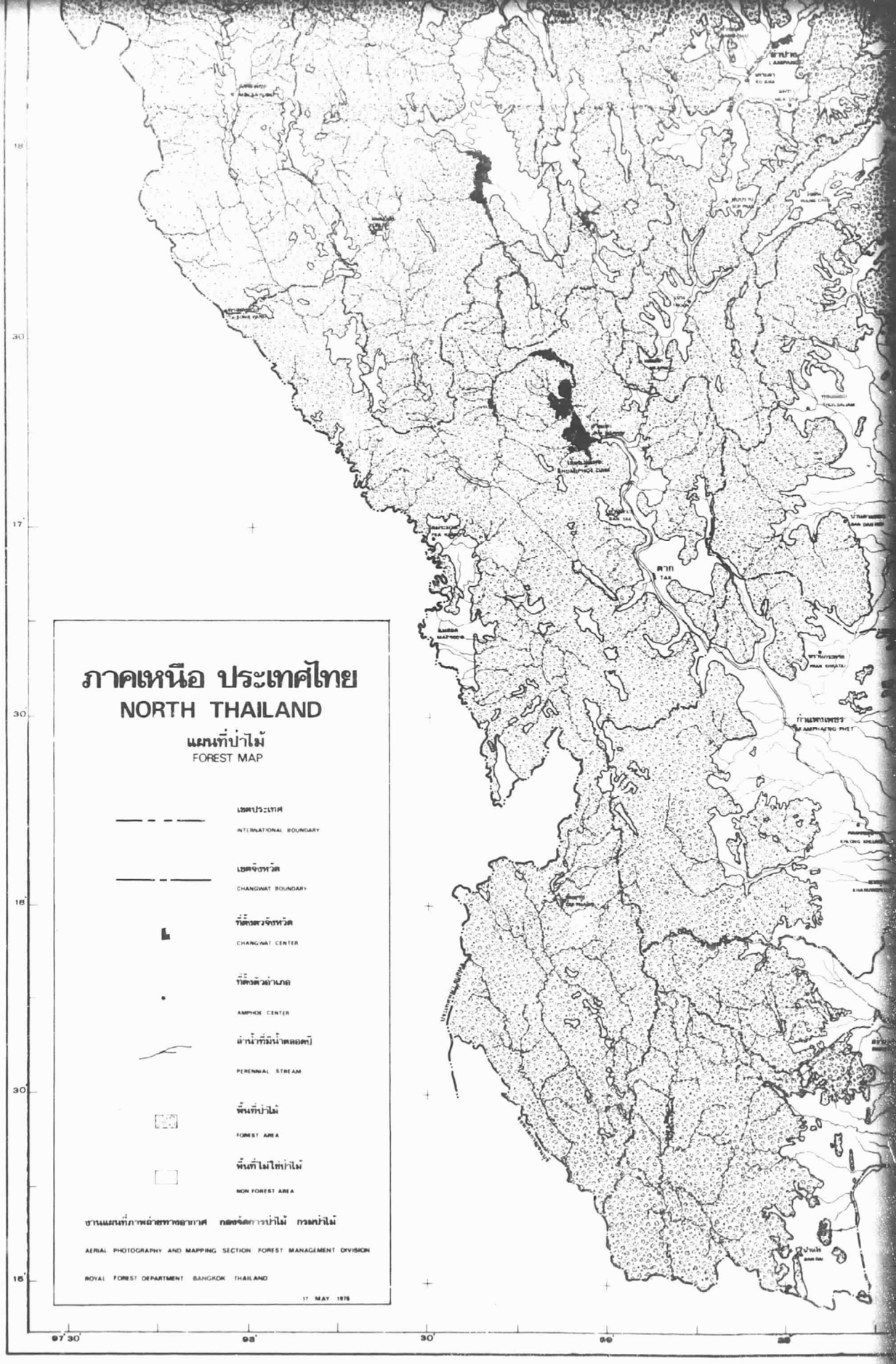


FOLDOUT FRAME

39a


FOLDOUT FRAME 2
PHOTO INDEX
LOCATION DIAGRAM
N
มาตราส่วน 1:1500,000
SCALE 1:1,500,000
TOPOGRAPHIC MAP INDEX

FOLDOUT FRAME 1



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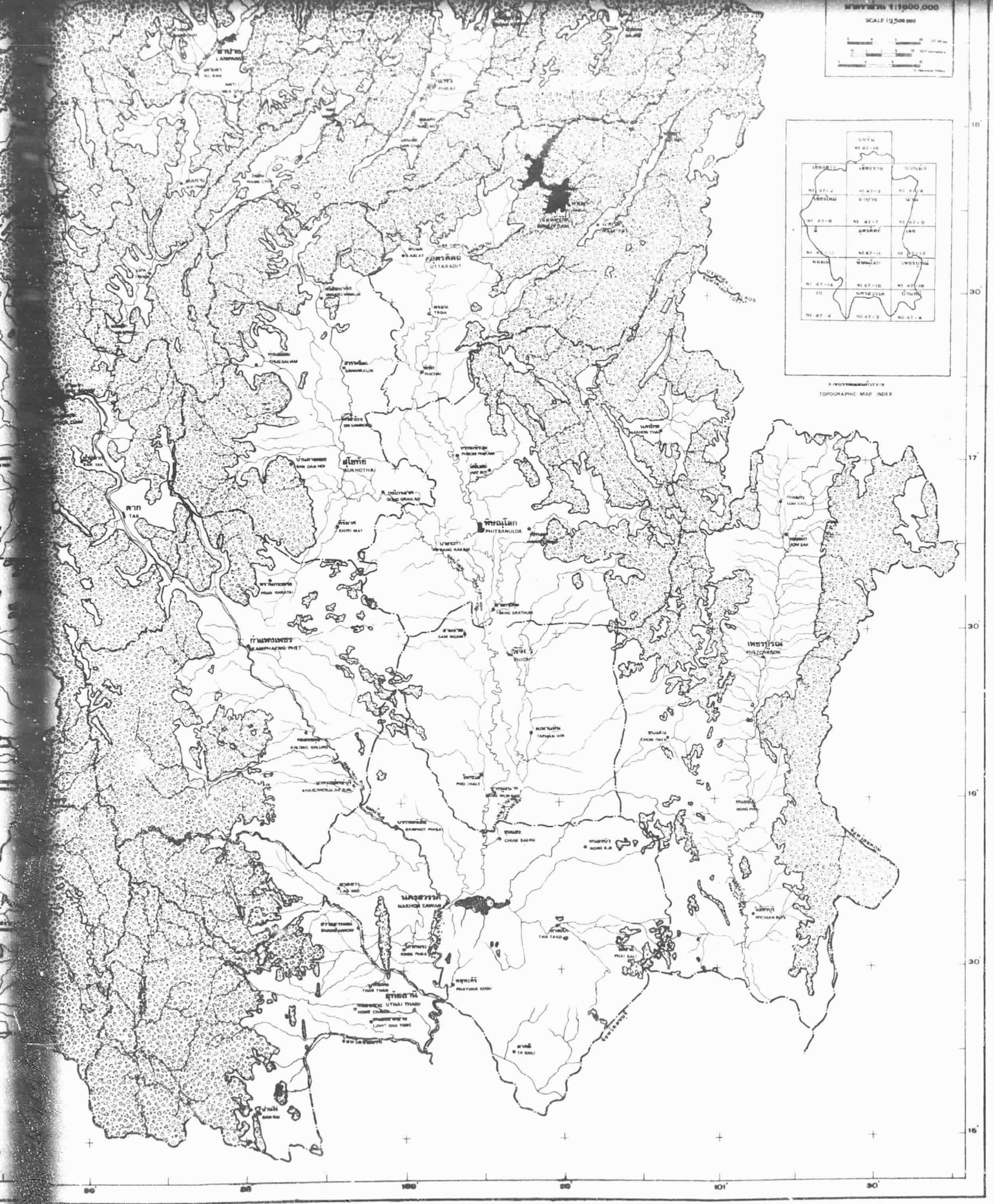
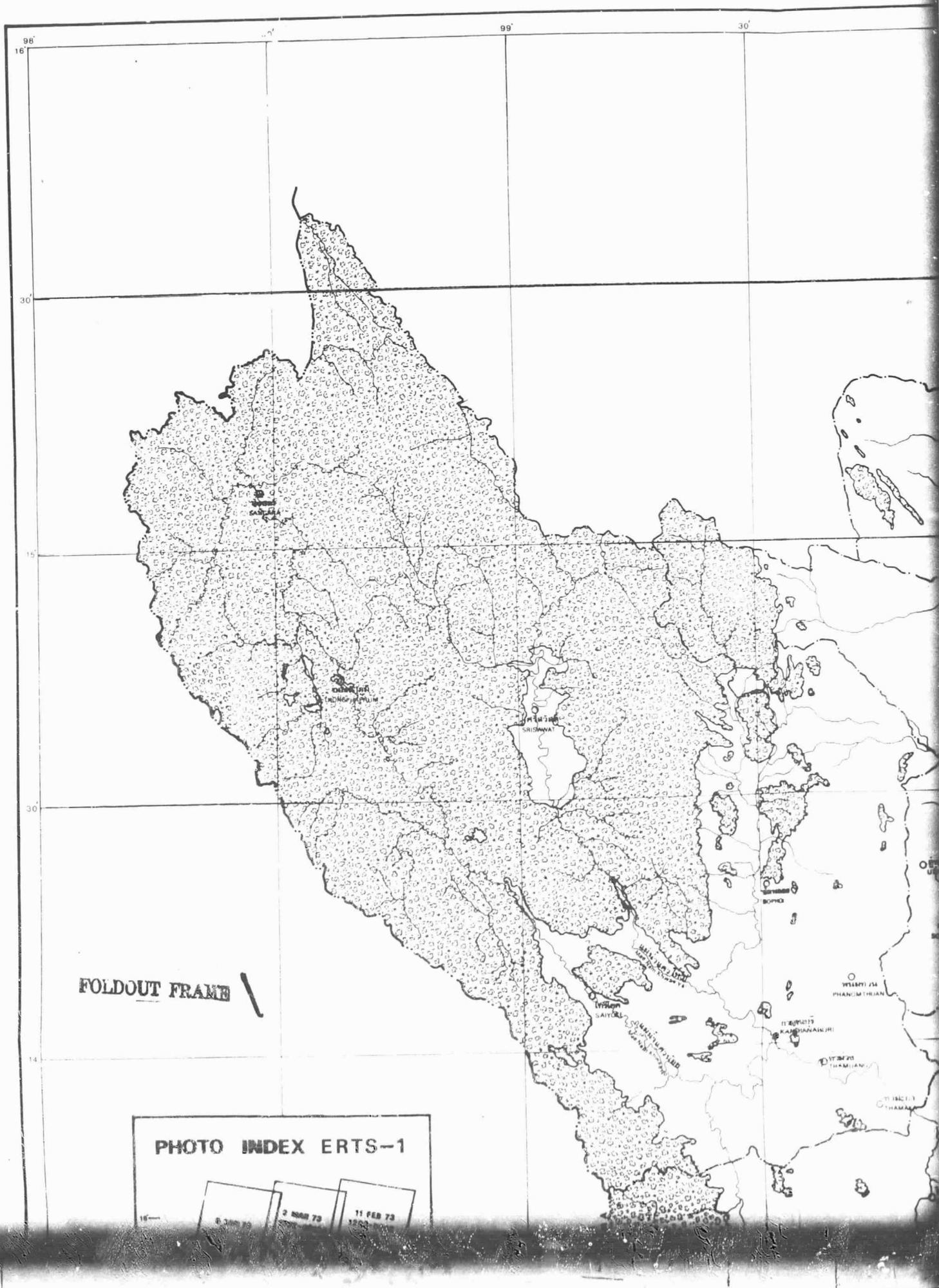
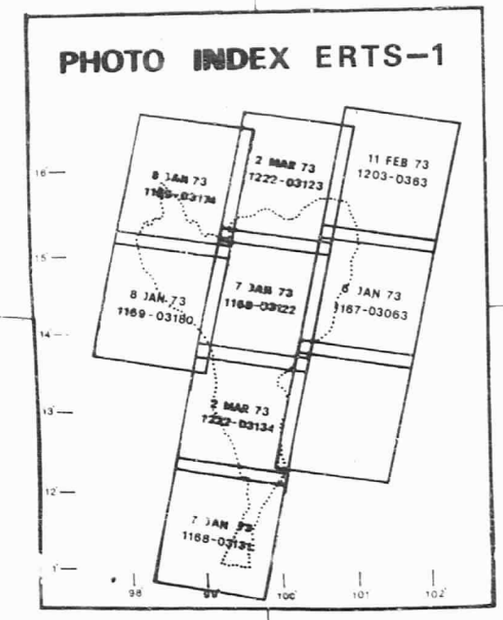
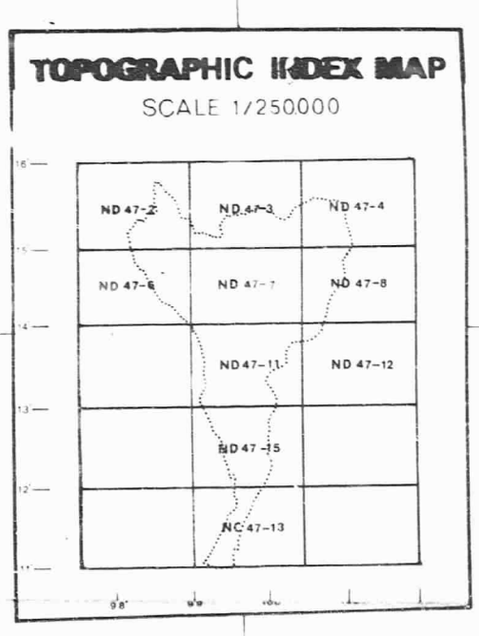


FOLDOUT FRAME 4


98°
99°
30'
16°
15°
14°
SRISAWAT
SAIYOK
BOPHO
PHANOM THUAN
KANCHANADIT
THAMUANG
FOLDOUT FRAME
PHOTO INDEX ERTS-1
2 MAR 73
11 FEB 73


100°
30'
101°
30'
102°
15°
30'
14°
ชัยนาท
CHAINAT
สระบุรี
SARABURI
สิงห์บุรี
SINGBURI
ลพบุรี
LOPBURI
สุพรรณบุรี
SUPHANBURI
อยุธยา
AYUDHAYA
กรุงเทพฯ
BANGKOK
FOLDOUT FRAME 2
FOLDOUT FRAME 4

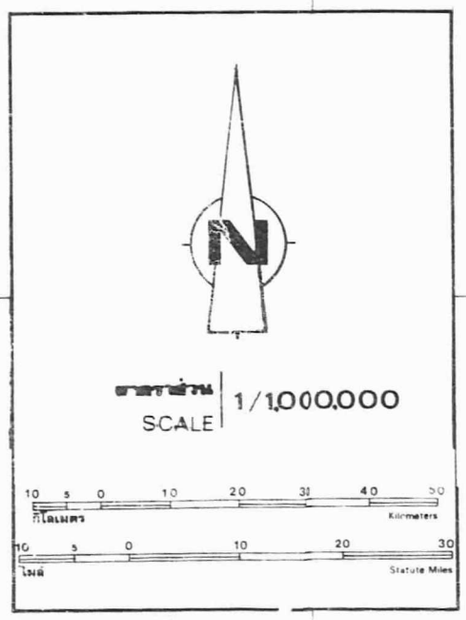




FOLDOUT FRAME 3

งานแผนที่ภาพถ่ายทางอากาศ
กองจัดการป่าไม้ กรมป่าไม้

AERIAL PHOTOGRAPHY AND MAPPING SECTION



ภาคกลาง ประเทศไทย

CENTRAL THAILAND

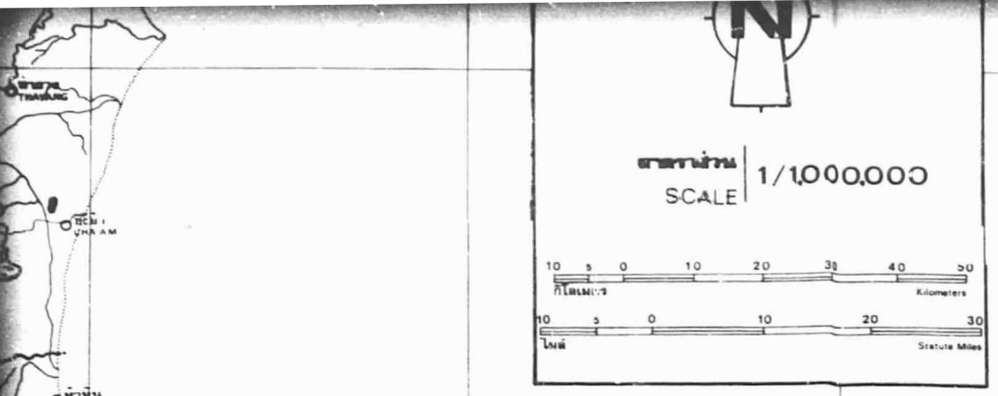
แผนที่ป่าไม้

FOREST MAP

เครื่องหมาย
LEGEND

- พื้นที่ป่าไม้ FOREST AREA
- พื้นที่ไม่ใช่ป่าไม้ NON-FOREST AREA
- เขตระหว่างประเทศ INTERNATIONAL BOUNDARY
- เขตจังหวัด CHANGWAT BOUNDARY
- เขตป่า FOREST BOUNDARY
- แม่น้ำ คลอง ห้วย MAENAM KHLONG HUAI
- ที่ตั้งจังหวัด CHANGWAT CENTER
- ที่ตั้งอำเภอ AMPHOE CENTER

FOLDOUT FRAME 5



ภาคกลาง ประเทศไทย

CENTRAL THAILAND

แผนที่ป่าไม้

FOREST MAP

เครื่องหมาย
LEGEND

พื้นที่ป่าไม้ FOREST AREA	พื้นที่ไม่ใช่ป่าไม้ NON-FOREST AREA
เขตระหว่างประเทศ INTERNATIONAL BOUNDARY	เขตจังหวัด CHANGWAT BOUNDARY
เขตป่า FOREST BOUNDARY	แม่น้ำ คลอง ห้วย MAENAM KHLONG HUAI
ที่ตั้งจังหวัด CHANGWAT CENTER	ที่ตั้งอำเภอ AMPHOE CENTER

บันทึกสำหรับผู้ใช้

รายละเอียดบนแผนที่นี้อาศัยภาพถ่ายจากดาวเทียม ERTS-1, MSS, Band 5 **ประกอบกับการตรวจสอบทางภาคพื้นดินเมื่อปี พ.ศ.๒๕๐๗**

NOTE TO USER

The information on this map is based on the application of the recognition of ERTS-1, MSS Band 5 with some ground checks,1974.

NOV. 74

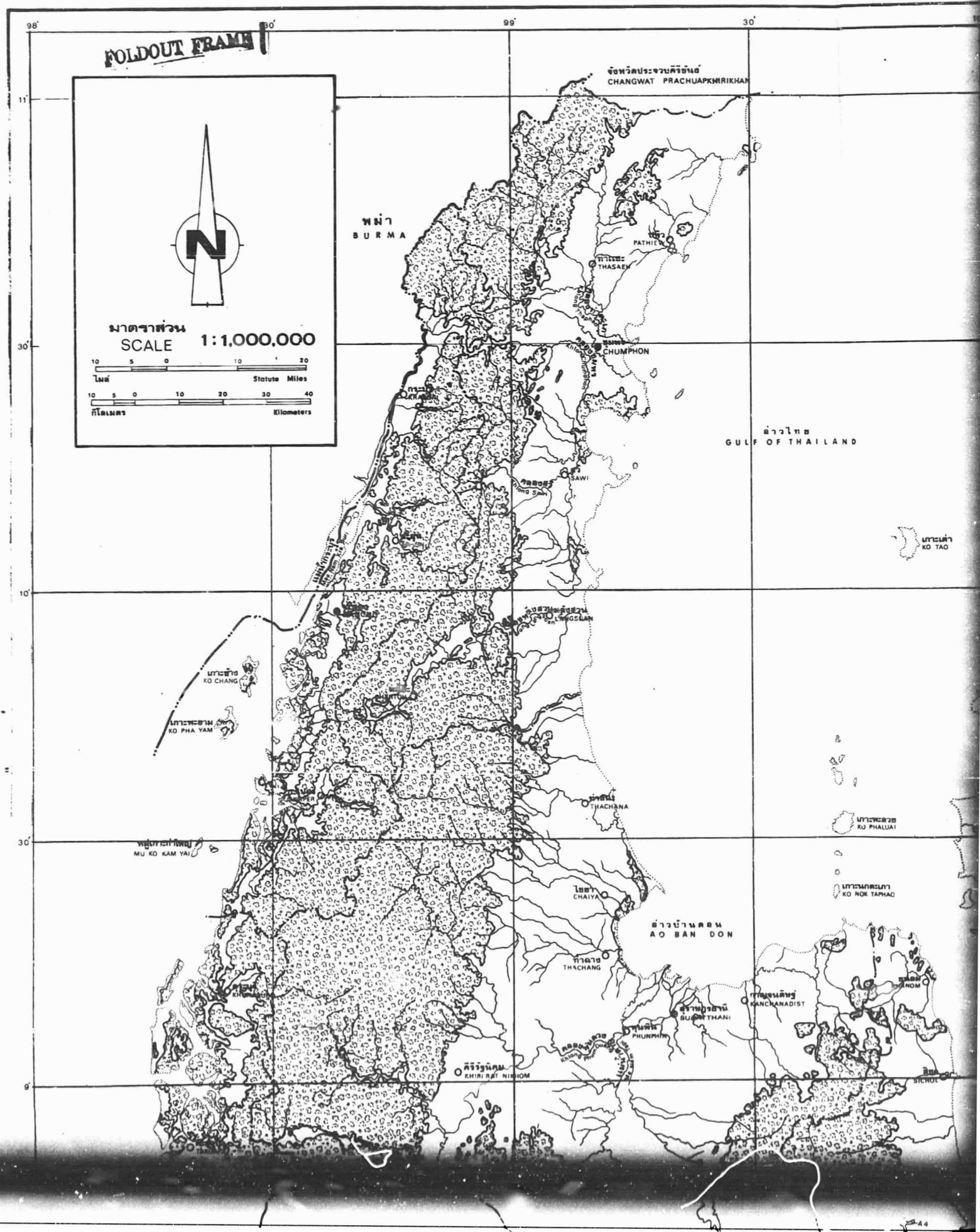
พ.ศ. 17

100° 30' 101° 30' 102°

FOLDOUT FRAME 4

41

FOLDOUT FRAME



41

41-c

ภาคใต้ ประเทศไทย

SOUTH THAILAND

แผนที่ป่าไม้

FOREST MAP

FOLDOUT FRAME 2

เรื่องหมาย
LEGEND

พื้นที่ป่าไม้ FOREST AREA	พื้นที่ไม่ใช่ป่าไม้ NON-FOREST AREA
เขตระหว่างประเทศ INTERNATIONAL BOUNDARY	เขตจังหวัด CHANGWAT BOUNDARY
เขตป่า FOREST BOUNDARY	แม่น้ำ คลอง ห้วย MAENAM KHLONG HUAI
ที่ตั้งจังหวัด CHANGWAT CENTER	ที่ตั้งอำเภอ AMPHOE CENTER

บันทึกสำหรับผู้ใช้

รายละเอียดบนแผนที่นี้อาศัยภาพถ่ายจากดาวเทียม ERTS-1 MSS Band 5 ประกอบกับการตรวจสอบทางภาคพื้นดินเมื่อปี พ.ศ. ๒๕๑๗

NOTE TO USER

The information on this map is based on the application of the recognition of ERTS-1 MSS Band 5 with some ground checks.1974

JAN 75.

พ.ศ. ๑๘

เกาะพะงัน
KO PHA-NGAN

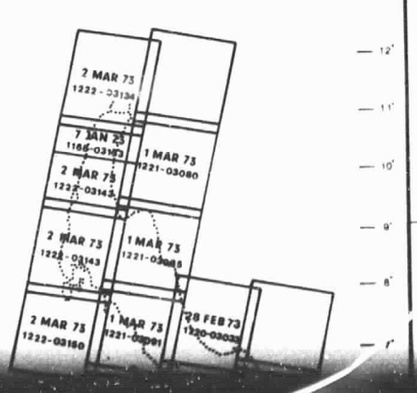
เกาะสมุย
KO SAMUI

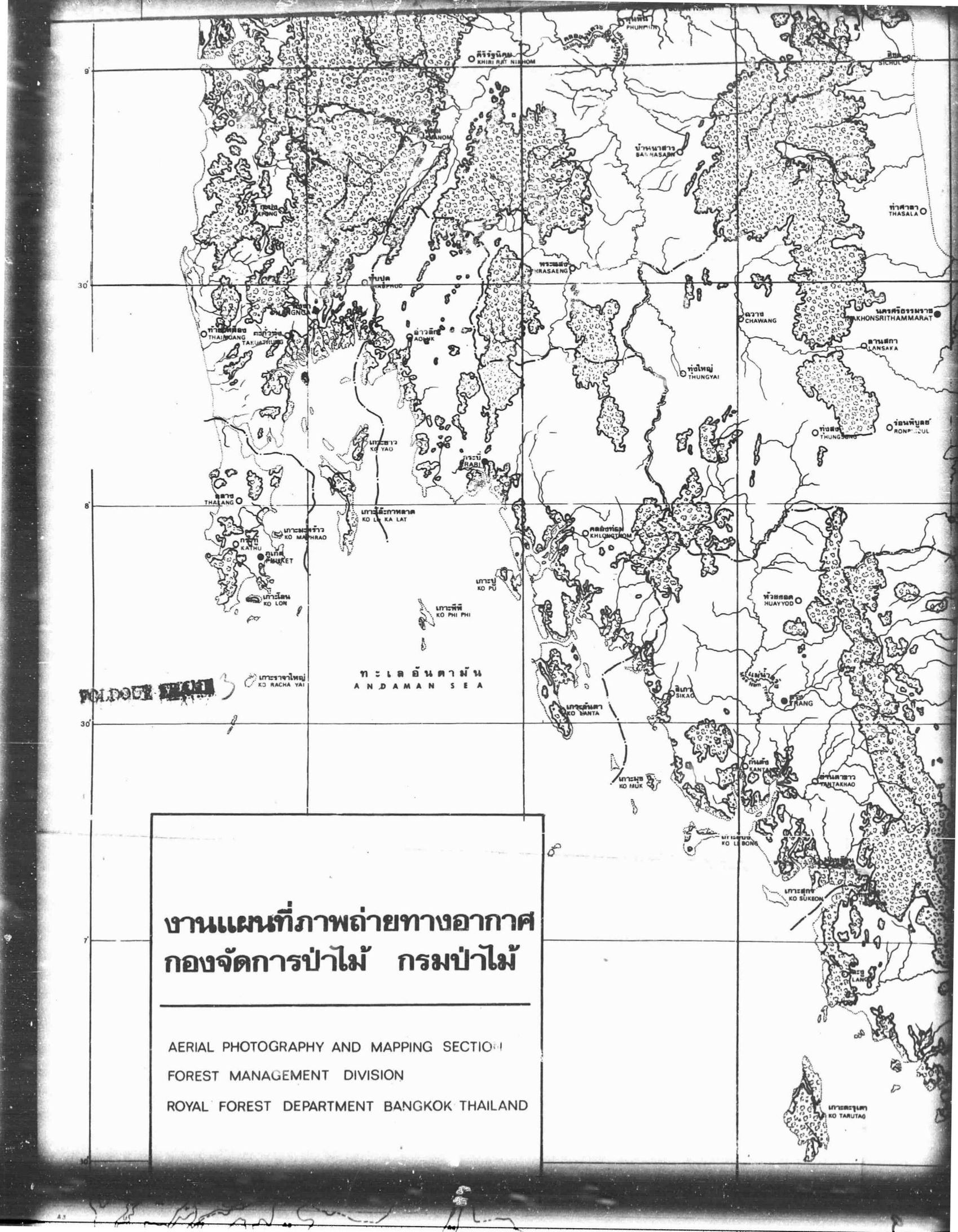
ทะเลจีนใต้
SOUTH CHINA SEA

TOPOGRAPHIC INDEX MAP
SCALE 1/250,000

NC 47-2	NC 47-3
NC 47-6	NC 47-7
NC 47-10	NC 47-11
NC 47-14	NC 47-15
NB 47-2	NB 47-3

PHOTO INDEX ERTS-1



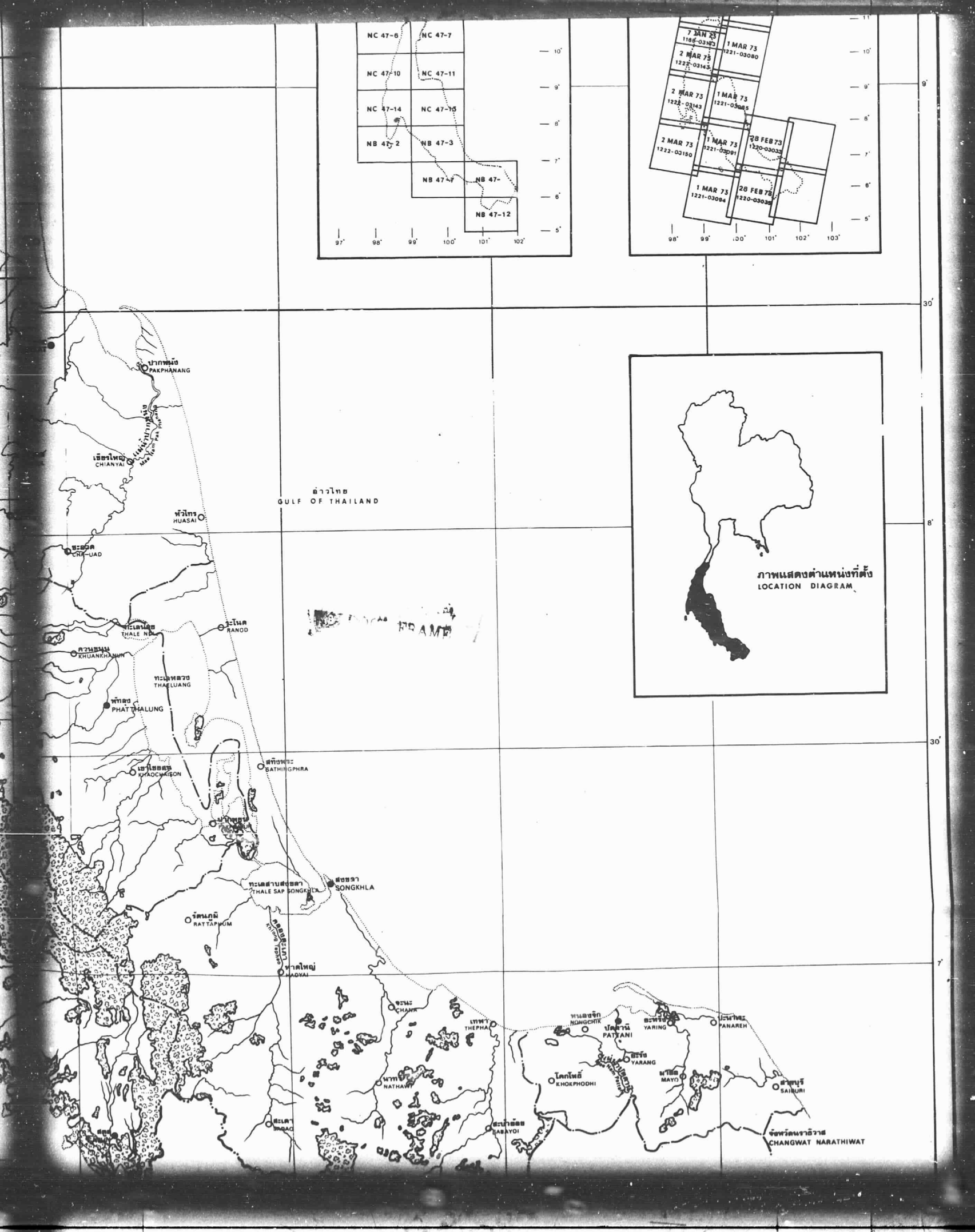


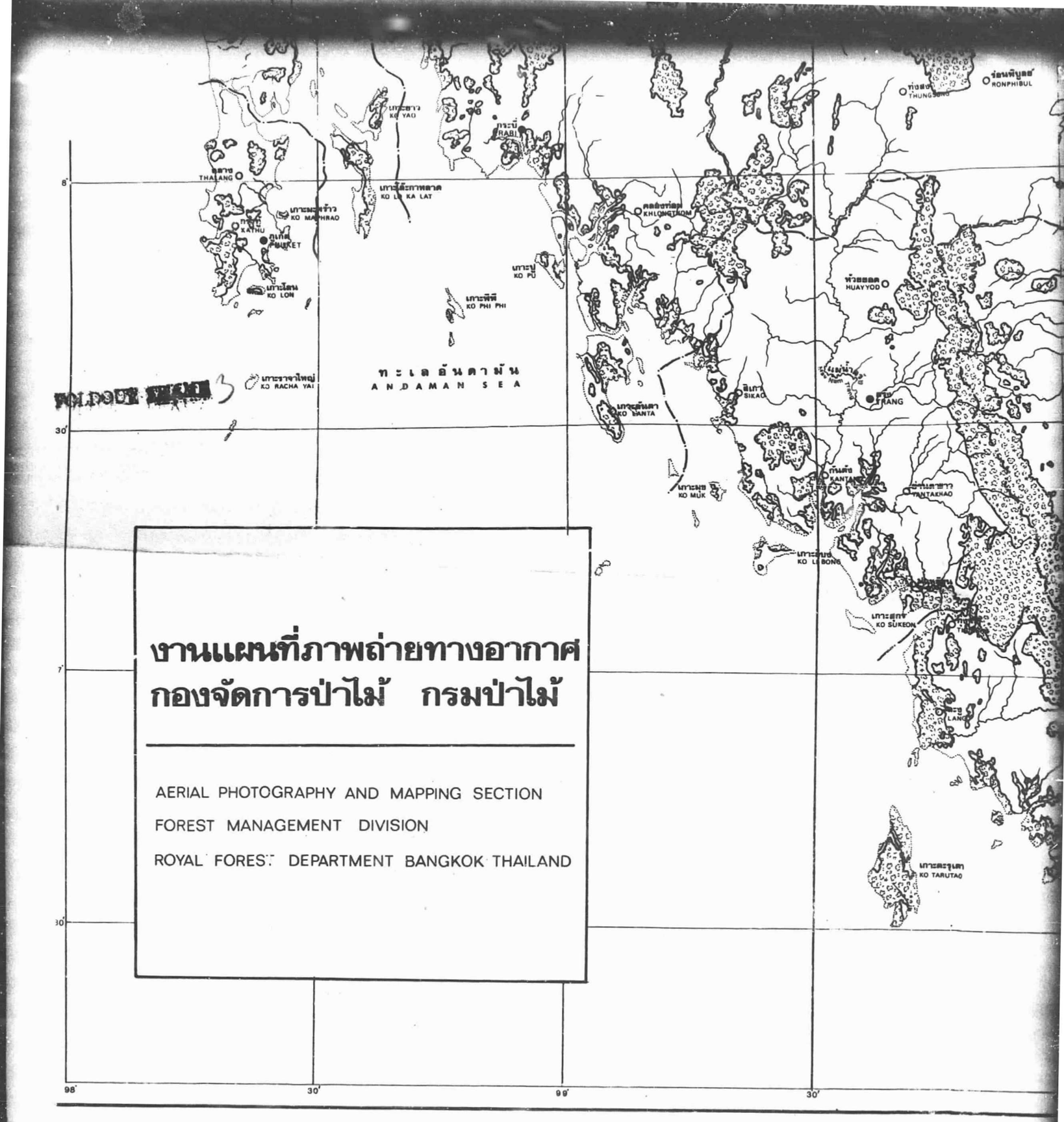
งานแผนที่ภาพถ่ายทางอากาศ
กองจัดการป่าไม้ กรมป่าไม้

AERIAL PHOTOGRAPHY AND MAPPING SECTION

FOREST MANAGEMENT DIVISION

ROYAL FOREST DEPARTMENT BANGKOK THAILAND


NC 47-6
NC 47-7
NC 47-10
NC 47-11
NC 47-14
NC 47-15
NB 47-2
NB 47-3
NB 47-7
NB 47-
NB 47-12
7 JAN 73
1166-03163
1 MAR 73
1221-03080
2 MAR 73
1222-03143
1 MAR 73
1221-03085
2 MAR 73
1222-03150
1 MAR 73
1221-03091
28 FEB 73
1220-03033
1 MAR 73
1221-03094
28 FEB 73
1220-03034
97°
98°
99°
100°
101°
102°
103°
10°
9°
8°
7°
6°
5°
ภาพแสดงตำแหน่งที่ตั้ง
LOCATION DIAGRAM
ปากพนัง
PAKPHANANG
เชียงใหญ่
CHIANYAI
อ่าวไทย
GULF OF THAILAND
หัวไทร
HUASAI
ระแงะ
RANOD
ทะเลน้อย
THALE NOI
ควนขนุน
KHUANKHANUN
ทะเลหลวง
THALUANG
พัทลุง
PHATTHALUNG
เขาไอยคีรี
KHAOCHAIKHIRI
สทิงพระ
SATHINGPHRA
ทะเลสาบสงขลา
THALE SAP SONGKHLA
สงขลา
SONGKHLA
รัตนภูมิ
RATTAPHUM
หาดใหญ่
HADYAI
จะนะ
CHANA
เทพา
THEPHA
นาทวี
NATHAWI
สะเดา
SADAO
สะบ้าย้อย
SABAYOI
หนองจิก
NONGCHIK
ปัตตานี
PATTANI
ยะหริ่ง
YARING
ปะนาเระ
PANAREH
ยะรัง
YARANG
โคกโพธิ์
KHOKPHODHI
มายอ
MAYO
สายบุรี
SAIBURI
จังหวัดนราธิวาส
CHANGWAT NARATHIWAT



FOLDOUT FRAME 3

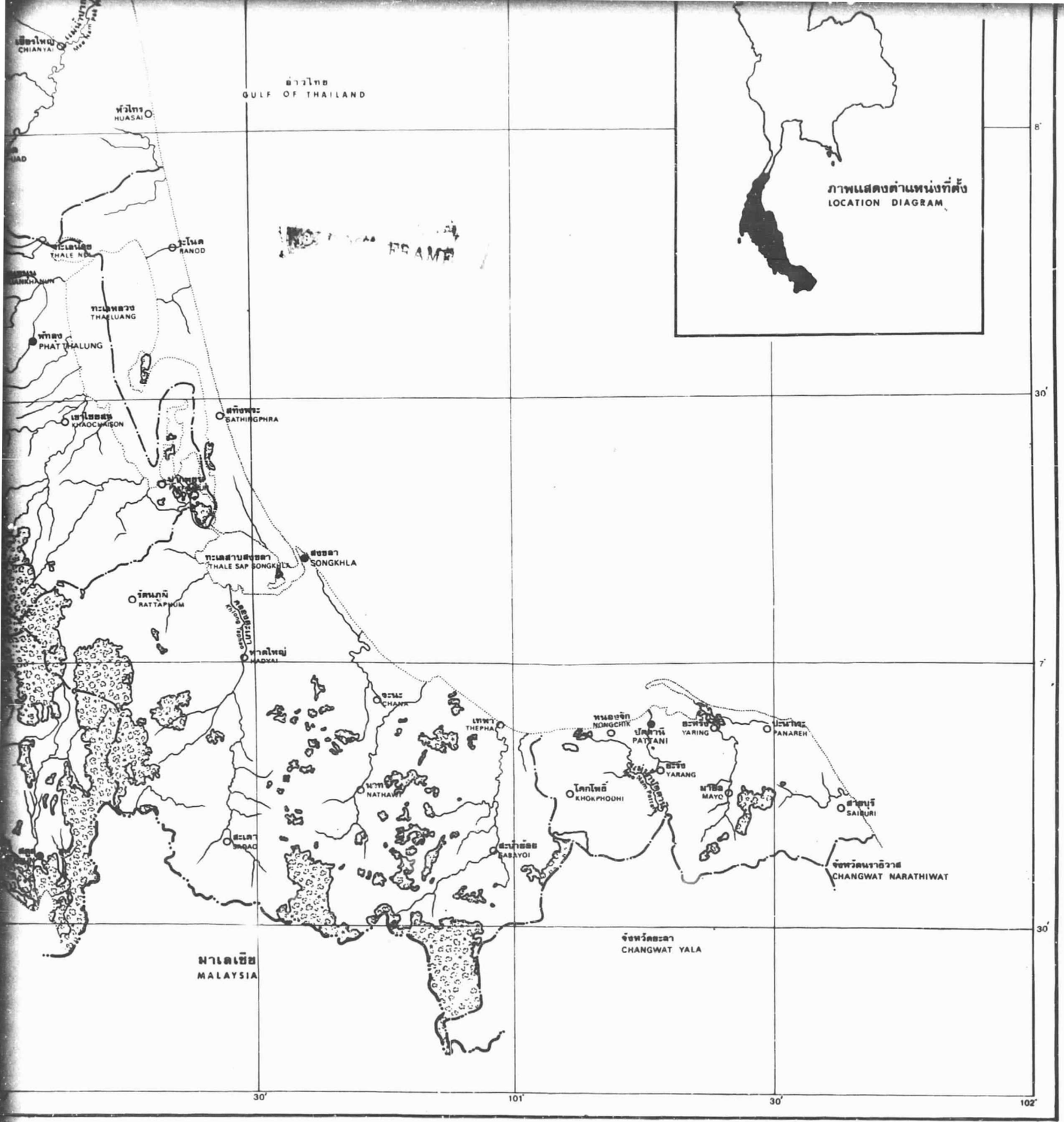
งานแผนที่ภาพถ่ายทางอากาศ กองจัดการป่าไม้ กรมป่าไม้

AERIAL PHOTOGRAPHY AND MAPPING SECTION

FOREST MANAGEMENT DIVISION

ROYAL FORES.. DEPARTMENT BANGKOK THAILAND

FOLDOUT FRAME 5



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Land Use Inventory of North Thailand Using Landsat Imagery

Reported by

Manu Omakupt

Land Classification Division, Department of Land Development

Ministry of Agriculture and Cooperatives

I. Objectives

The land use classification and mapping program of the Department of Land Development is aimed at producing land use maps of the entire Kingdom. With the introduction of Landsat imagery into Thailand, the program has been intensified to enable updating of existing land use maps in a reasonable time and to identify and differentiate various types of crops with the aid of Landsat imagery. Experience gained from studying of Landsat-1 imagery was used in the existing program with the purpose of producing land use maps of the whole country at scale of 1:500,000 based on Landsat-2 imagery. Due to manpower constraints and lack of reasonable cloud-free Landsat-2 imagery in some parts of the country, this report will present the results obtained so far which deals only with the land use of North Thailand.

II. Procedure

Thirteen frames of black and white prints at 1:500,000 and 1:250,000 scale of Landsat-2 imagery of band 5 and band 7 and diazochromes of 1:1,000,000 supplied by the Working Unit of TNRSP were used in the study. Topographic maps at 1:250,000 Series L 1501 of the Royal Thai Survey Department were also used for comparisons. Direct visual interpretation was performed based on texture, gray tone, size and shape, temporal change, environment and topography. Ground truth observations were carried out during August - October 1976 for test areas. Similar or uniform tones are taken as representatives of the land use types in the area.

The land use classification scheme developed during Landsat-1 Investigation and reported earlier in our final report to NASA was used in the present study.

III. Results

North Thailand consists of sixteen provinces (called Changwat in Thai language) covering an area of 170,011 square kilometers or 106,256,875 rais (rai is the Thai unit for area measurement and is equal to 1600 square meters; therefore one square kilometer equals 625 rais). The numerous mountain ranges in this area are origins of major tributaries of Chao Phya River which flows through Central Plain and Bangkok. The most important

forested areas and watersheds are also located in North Thailand. The results of the study enable classification of land use conditions in North Thailand as follows:

Land use type	Area rais (sq.km.)	Percent
Urban land (U)	182,812 (292.5)	0.17
Horticultural land (A1)	17,500 (28.0)	0.02
Perennial land (A2)	193,281 (309.2)	0.18
Field Crop land (A3)	9,266,562 (14,826.5)	8.72
Paddy land (A4)	16,938,906 (27,102.2)	15.94
Pasture land (A5)	104,375 (167.0)	0.10
Forest land (F)	78,608,596 (125,773.8)	73.98
Water Body (W)	601,562 (962.5)	0.57
Miscellaneous land (M)	343,281 (549.2)	0.32
Total	106,256,875 (170,011)	100

IV. Conclusion and Discussion

The land use map of North Thailand at scale of 1:1,000,000 based on photo-interpretation of Landsat-2 imagery is shown in Figure 1. This land use map is being used in the land development planning and other related projects by government planning agencies. It has been found out from this study that band 5 of Landsat MSS imagery provides maximum information and best discrimination of vegetation. Experience leads to the conclusion that small scale satellite imagery can be used in the broad land use survey with accurate results. Moreover, it is more economical, involving less time and less expense when compared with other surveying methods. Satellite survey is most suitable in the studying and monitoring of land use changes which tend to occur rapidly. It is also very useful in the survey to obtain up-to-date information on land use. The Department of Land Development is working on other areas of Thailand in the program to produce land use maps of the whole country based on Landsat imagery. With the capability to process Landsat CCT's in Thailand, the Department of Land Development is cooperating with other groups in an effort to produce computer processed land use maps and in the evaluation of the results.

LAND USE CLASSIFICATION

URBAN LAND (U)

- U 1. Residential land
  - U 1.1 City, Town
  - U 1.2 Village (strip and clustered settlement)
- U 2. Commercial land
- U 3. Institutional land (school, hospital, park, temple)
- U 4. Transportational land (railroad yard, bus station, airfield, etc.)
- U 5. Industrial land
  - U 5.1 Mine and dump
  - U 5.2 Factory

AGRICULTURAL LAND (A)

- A 1. Horticultural land
  - A 1.1 Truck crop land
  - A 1.2 Ornamental plant garden
  - A 1.3 Vine yard
  - A 1.4 Other horticultural land
- A 2. Perennial crop land
  - A 2.1 Orchards
    - A 2.1.1 Mixed orchard
    - A 2.1.2 Citrus orchard
    - A 2.1.3 Durian orchard
    - A 2.1.4 Rambutan orchard
    - A 2.1.5 Longan orchard
    - A 2.1.6 Litchi orchard
    - A 2.1.7 Mango orchard
    - A 2.1.8 Custard apple orchard
    - A 2.1.9 Jujube orchard
    - A 2.1.10 Peach orchard
    - A 2.1.11 Apple orchard
    - A 2.1.12 Other orchard
  - A 2.2 Rubber plantation
  - A 2.3 Coconut plantation
  - A 2.4 Banana plantation
  - A 2.5 Kapok plantation

A 2.6 Coffee plantation

A 2.7 Tea plantation

A 2.8 Miang tea plantation

A 2.9 Oil palm plantation

A 2.10 Mulberry plantation

A 2.11 Pepper plantation

A 2.12 Bamboo plantation

A 2.13 Sugar palm plantation

A 2.14 Raintree plantation

A 2.15 Other plantation

A 3. Field crop land

A 3.1 Corn field

A 3.2 Sugar cane field

A 3.3 Cassava field

A 3.4 Cotton field

A 3.5 Tobacco field

A 3.6 Pineapple field

A 3.7 Soybean field

A 3.8 Mung bean field

A 3.9 Red bean field

A 3.10 Peanut field

A 3.11 Fiber crop (kenaf, jute)

A 3.12 Melon field

A 3.13 Castor bean field

A 3.14 Sorghum field

A 3.15 Sesame field

A 3.16 Upland rice field

A 3.17 Irish potato field

A 3.18 Sweet potato field

A 3.19 Mint field

A 3.20 Chili field

A 3.21 Other field crop land

A 4. Paddy land

A 4.1 Broadcast rice field

A 4 1.1 One crop only

A 4.1.2 Double cropping with second crop

A 4.2 Transplanted rice field

A 4.2.1 Rainfed, crop only

A 4.2.2 Rainfed, double cropping with second crop

A 4.2.3 Irrigated, one crop only

A 4.2.4 Irrigated, double cropping

A 4.2.5 Irrigated, double or triple cropping in rotation with other crops

A 5. Pasture and range land

A 5.1 Improved pasture and range land

A 5.2 Unimproved pasture and range land

A 6. Swidden land

A 6.1 Noncyclical swidden land

A 6.1.1 Upland rice in rotation or association with other crops

A 6.1.2 Corn or opium in rotation or association with other crops

A 6.1.3 Other swidden crop land

A 6.2 Cyclical swidden land

A 6.2.1 Upland rice field

A 6.2.2 Other crop field

A 6.2.3 Bush fallow

Forest land (F)

F 1. Evergreen forest

F 1.1 Tropical evergreen forest

F 1.1.1 Hill evergreen forest

F 1.1.2 Dry evergreen forest

F 1.1.3 Moist evergreen forest

F 1.2 Coniferous forest

F 1.3 Mangrove forest

F 2. Deciduous forest

F 2.1 Mixed deciduous forest

F 2.1.1 Mixed deciduous forest, with teak

F 2.1.2 Mixed deciduous forest, no teak

F 2.1.3 Bamboo forest

F 2.2 Dry dipterocarp or deciduous dipterocarp forest

F 2.3 Scrub forest

F 3. Beach (Littoral) forest

F 4. Swamp forest

F 5. Forest plantation

F 5.1 Teak plantation

F 5.2 Pine plantation

F 5.3 Other plantation

Remark: put (-------) on every catagories that forest are disturbed

Water body (W)

W 1. Reservoirs, lakes, ponds

W 2. Fish ponds

W 3. Shrimp ponds

Miscellaneous land (M)

M 1. Salt flats

M 2. Marsh and swamp

M 3. Rocky land (stony, rock out crop)

M 4. Waste land (sand dune, river or coastal waste land)

M 5. Other miscellaneous land (currently unused land that is not classified as above)

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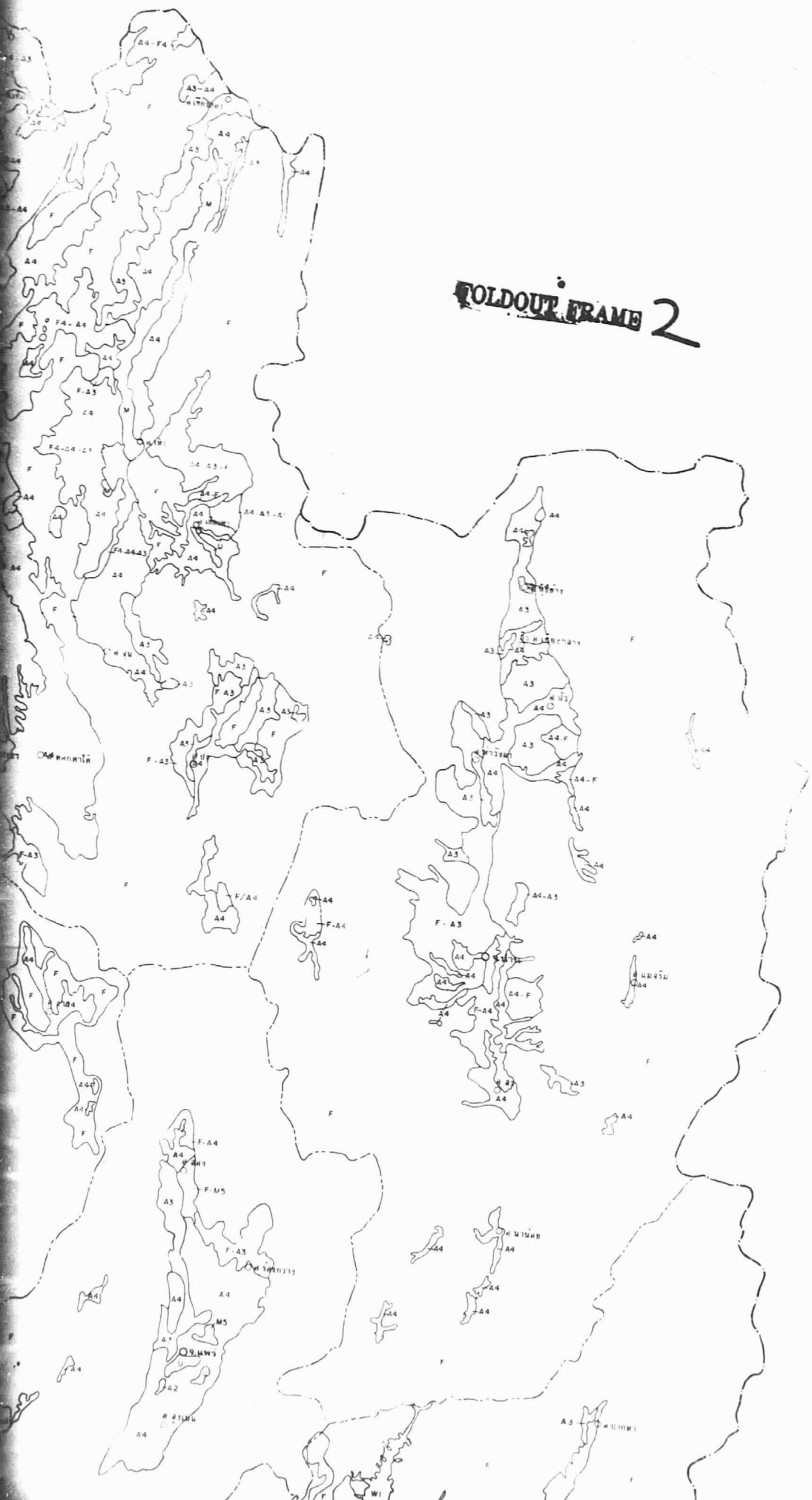

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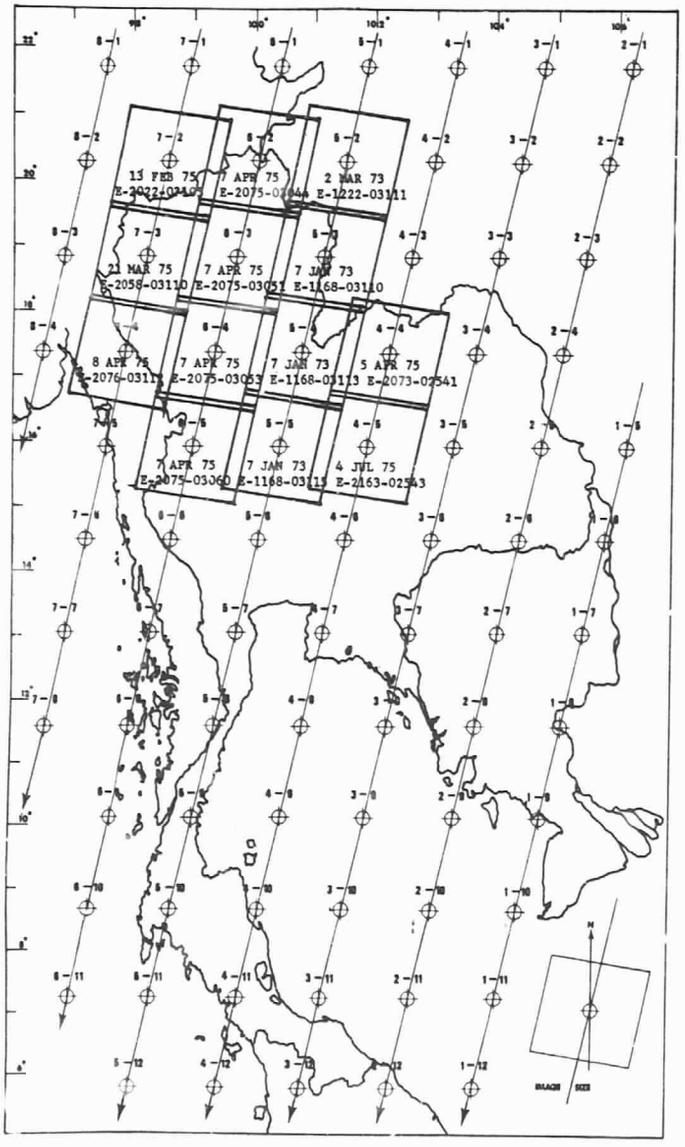
FOLDOUT FRAME 3



LAND USE MAP OF NORTH THAILAND

SCALE 1 : 1,000,000

Prepared by

Land Use Planning Section Land Classification Division

Land Development Department

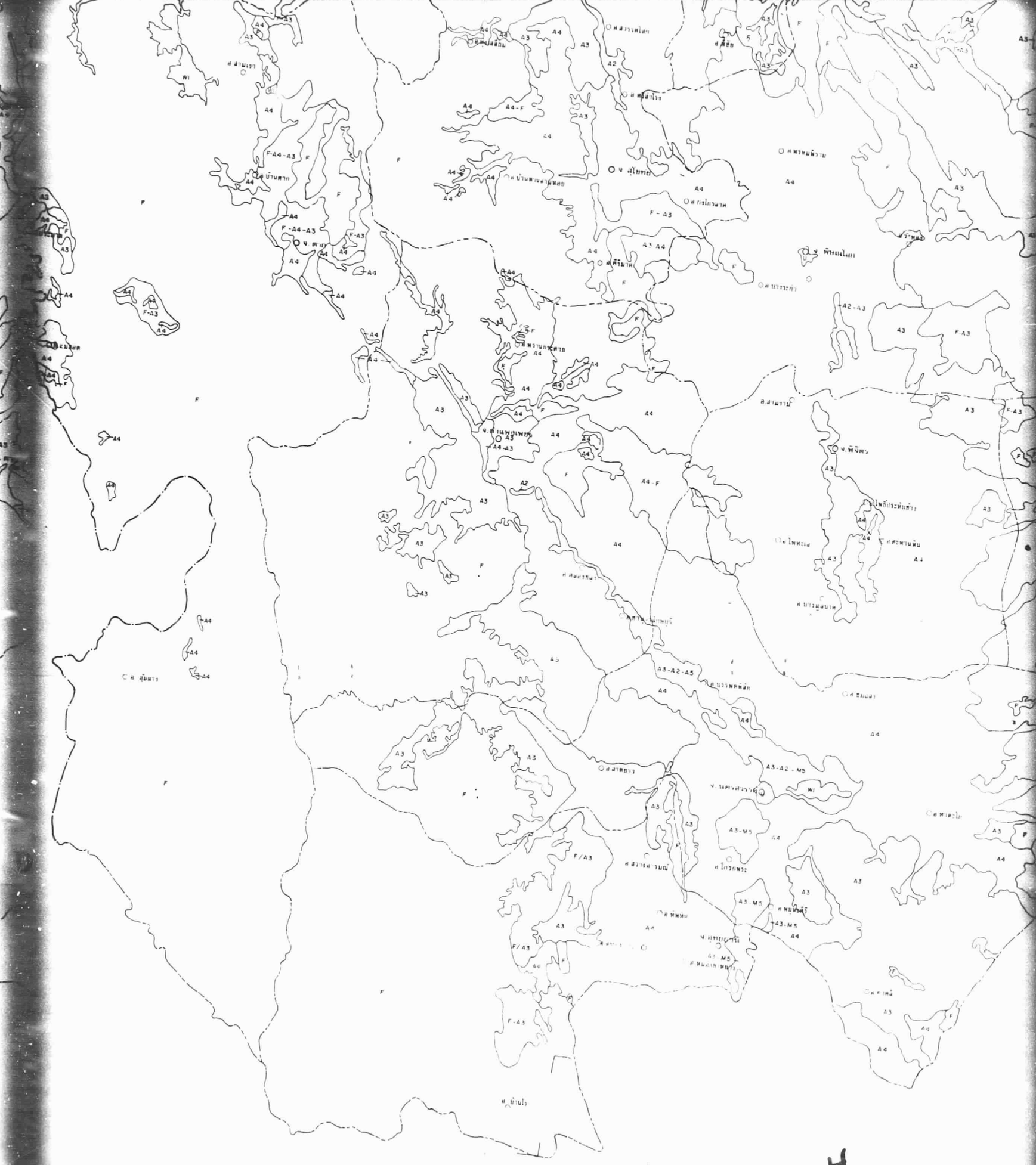


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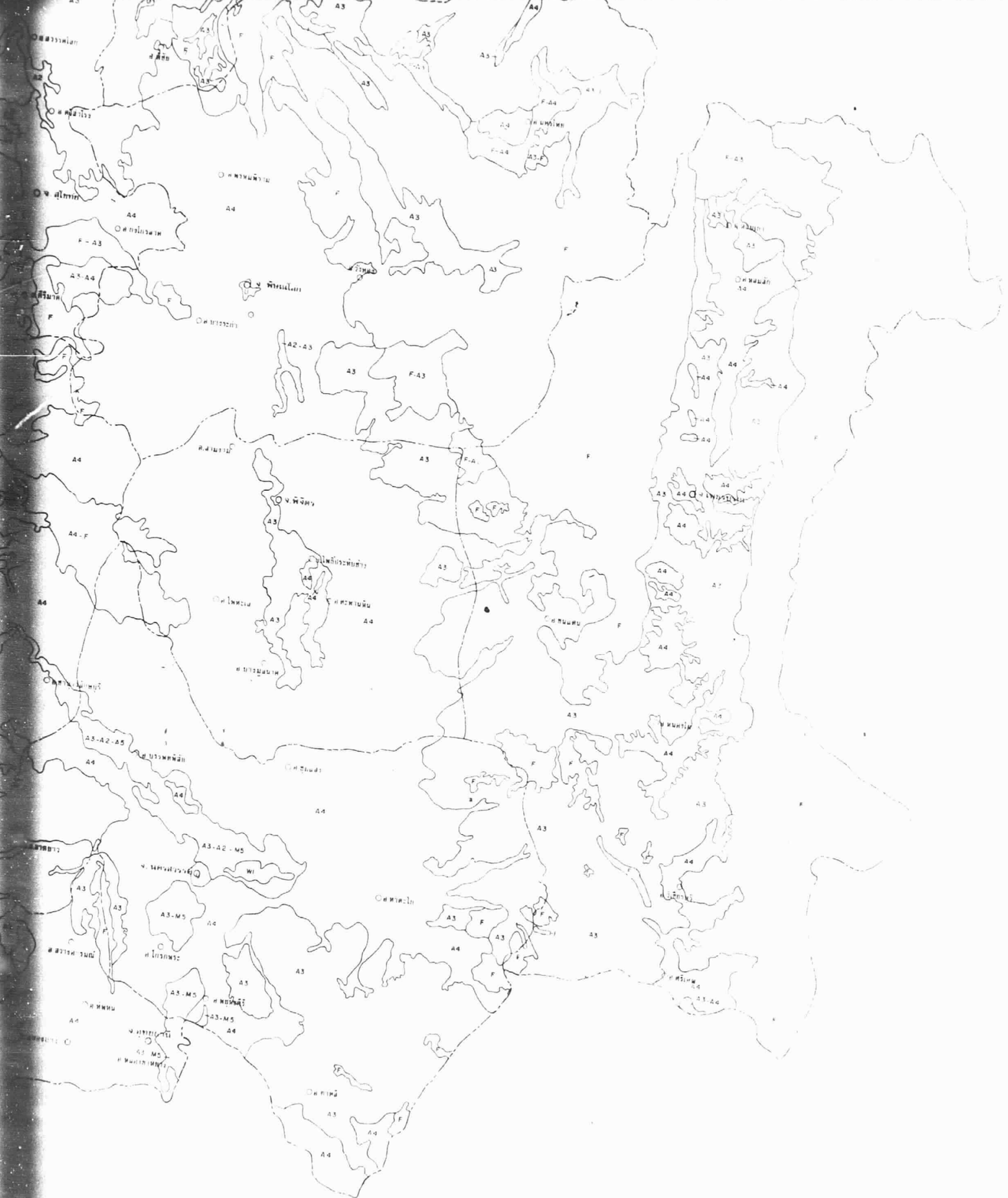
Figure 1.



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National Resources Evaluation of Khao Yai National Park by Landsat Imagery

Reported by

Dr. Sathit Wacharakitti

Faculty of Forestry, Kasetsart University

I. Introduction

Remote sensing including conventional photographs of earth resources from aircraft and satellite can acquire large quantities of data of significant value of forest and agriculture land-use planning. Multidate aerial photographs provide information on forest and agriculture land-use classification, and their changes. LANDSAT-1 imagery also allows land planners to examine landscape characteristics and the change of large areas. This report is attempted to discuss the use of black and white aerial photographs and satellite imagery to determine a forest depletion and forest/agriculture land-use evolution of Khao Yai National Park.

II. Objectives

The purposes of the study are:

1. to investigate the existing land-use of Khao Yai National Park.
2. to determine the changes and impact of the study area.
3. to evaluate the validity of LANDSAT imagery in tropical forest/agriculture land-use classification and tropical forest ecological studies of the study area.

III. The Study Area

The study area is located between north latitude 14° 7' and 14° 37', and between 101° 2' and 101° 37' east longitude, and includes approximately 5780 sq.km. The climate of the study area is milder and getting full impact of southwest monsoon causing heavy rainfall during July - October. The average rainfall is about 4000 mm, and it is heavier along the high ridges. The highest temperature is about 30°C during April - May and the lowest temperature is about 6°C during December - January.

The vegetation types covering the study area can be classified into five categories based on the structure, species composition, elevation and slope as follows: Mixed Deciduous Forest, Dry Evergreen Forest, Tropical Rain Forest, Hill Evergreen Forest and secondary growth.

The topographic elevation of the study area varies from approximately 250 m. to 1400 m. above mean sea level.

IV. General Approach

The photo-interpretation was performed on black and white aerial photographs of 1:50,000 scale and also on LANDSAT-1 imagery of the study area in order to classify and map the forest and agriculture land-use patterns and to determine the dynamic change. Ground surveys were conducted after land-use map had been prepared.

V. Results and Discussion

Forest Depletion

The forest depletion was determined by using the over-lays of land-use map compiled in 1962 and LANDSAT land-use map in 1973. Comparison of area measurements for each land-use category between these two dates provide initial estimates of increase or decrease in forest/agriculture land-use in the area.

The forest depletion rate can be calculated from the existing forest area of 434,700 hectares in 1962 compared to 284,900 hectares in 1973, or -3.77 % per annum. A concomitant increase appears in other competing land-uses. Savannah, paddy field, urban and built-up land, horticultural land increased from 8250, 134,875, 300 and 7775 hectares in 1962 to 46,950, 238,350, 350 and 12,925 hectares in 1973 respectively (+17.13%, +5.31%, +1.41%, and +4.73% per annum). Orchard and water body were not recognized in 1962, but in 1973 the area of orchard and water body were increased to 1250 and 1175 hectares respectively.(Table 1)

Table 1

Generalized land-use evolution in the study area between 1962 and 1973.

Area in sq.km.

Type of Land-use	1962	1973	Change in Area	Percentage (11 yrs) %	Change in Percentage (Yearly) %
1. Forest Land	4347.00	2849.00	-1498.00	-34.46	-3.77
2. Savannah	82.50	469.50	+ 387.00	+469.09	+17.13
3. Paddy Field	1348.75	2383.50	+1034.75	+ 76.72	+ 5.31
4. Urban and Built-up Land	3.00	3.50	+ 0.50	+ 16.67	+ 1.41
5. Horticultural Land	77.75	129.25	+ 51.50	+ 66.24	+ 4.73
6. Orchard	0.00	12.50	+ 12.50	-	
7. Water Body	0.00	11.75	+ 11.75	-	
Total	5859.00	5859.00			

The Impact of Khao Yai National Park

Evidence from the study showed that the forested area of Khao Yai National Park has been very well protected; the rate of forest depletion was very small, from 212,350 hectares in 1962 to 202,150 hectares in 1973 (-0.45 % per annum). A concomitant increase in the area of savannah and paddy field was from 4975 and 8400 hectares in 1962 to 5125 and 18450 hectares in 1973 (+0.27 % and 7.42 % per annum) respectively as tabulated in Table 2.

Table 2

Generalized land-use evolution in Khao Yai National Park boundary between 1962 and 1973.

Type of Land-use	Area in sq.km. 1962	1973	Change in Area	Change in Percentage (11 yrs.) %	Change in Percentage (Yearly) %
1. Forest Land	2123.50	2021.50	-102.00	-4.80	-0.45
2. Savannah	49.75	51.25	+1.50	+3.02	+0.27
3. Paddy Field	84.00	184.50	+100.50	+119.64	+7.42
Total	2257.25	2257.25			

Value of LANDSAT Imagery

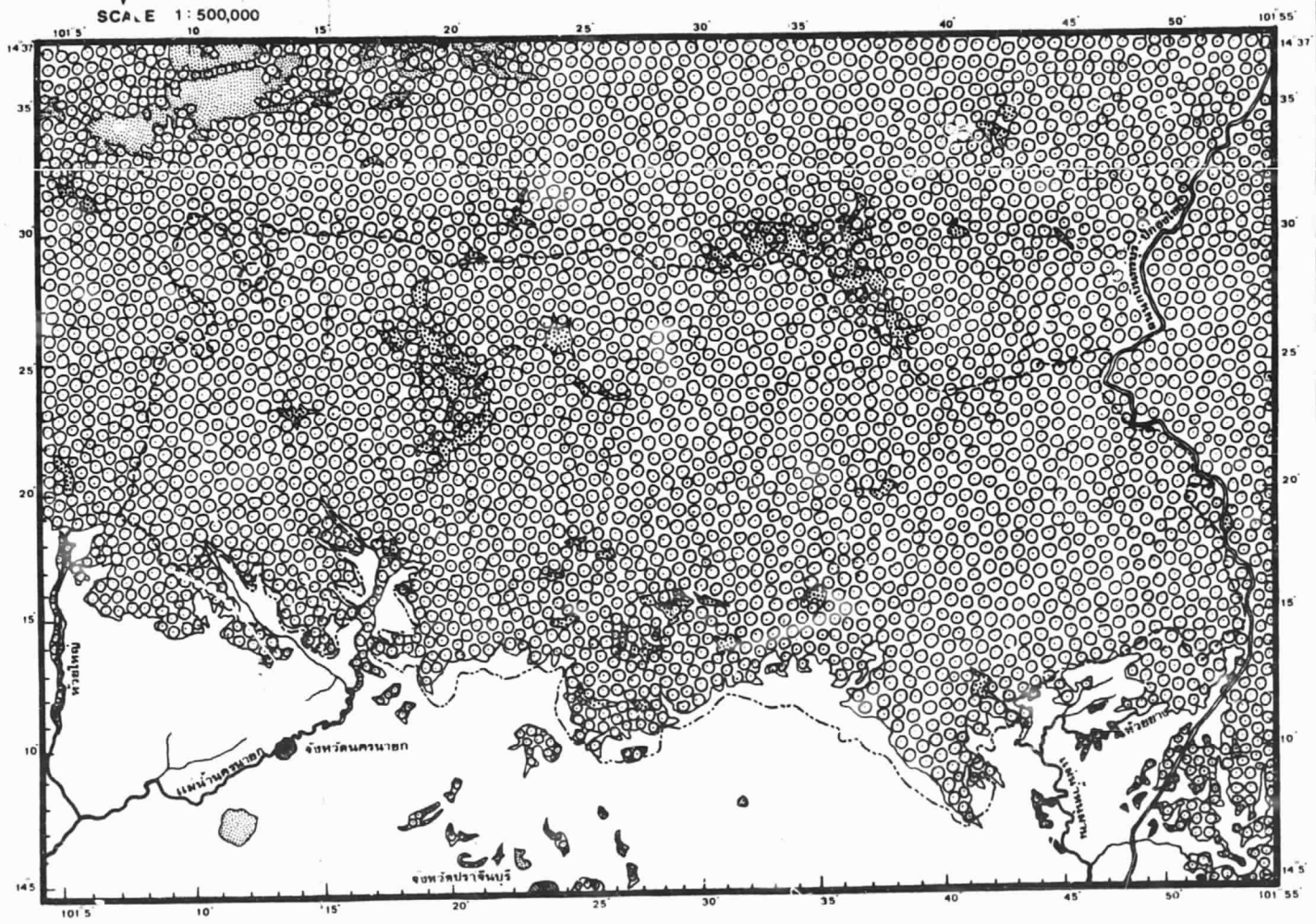
It can be concluded that MSS band 5 and color composites of bands 4,5 and 7 are valuable in broad land-use classification. Five land-use categories in the study area were identified on MSS band 5 and six categories classified on color composites at 1:250.000 scale.

Value of LANDSAT Imagery in Forest Ecology Studies.

Application of LANDSAT imagery in forest ecological and environmental studies of Khao Yai National Park is being conducted. More remote sensing data are being analyzed.

แผนที่แสดงการใช้ที่ดินบริเวณอุทยานแห่งชาติเขาใหญ่ ปี 2505

FOREST AND AGRICULTURAL LAND USE MAP OF KHAO YAI NATIONAL PARK IN 1962



เครื่องหมายแผนที่ (LEGEND)

- ตัวเมือง และสิ่งปลูกสร้าง (Urban and built up land)
- ป่าไม้ (Forest land)
- ทุ่งหญ้า (Savannah)
- นาข้าว (Paddy field)
- พืชสวน (Horticultural land)
- ถนน (Road)
- แนวเขตอุทยานแห่งชาติ (National park boundary)
- แม่น้ำ และ ห้วย (River and stream)
- จังหวัด (Changwat)

This map was prepared from topographic map of 1:250,000 scale of the year 1962 and the map showing Khao Yai National Park boundary of The Royal Forestry Department at scale of 1:250,000 of the year 1962. The purpose of this map is to compare with the land use map interpreted from Landsat imagery taken in 1973.

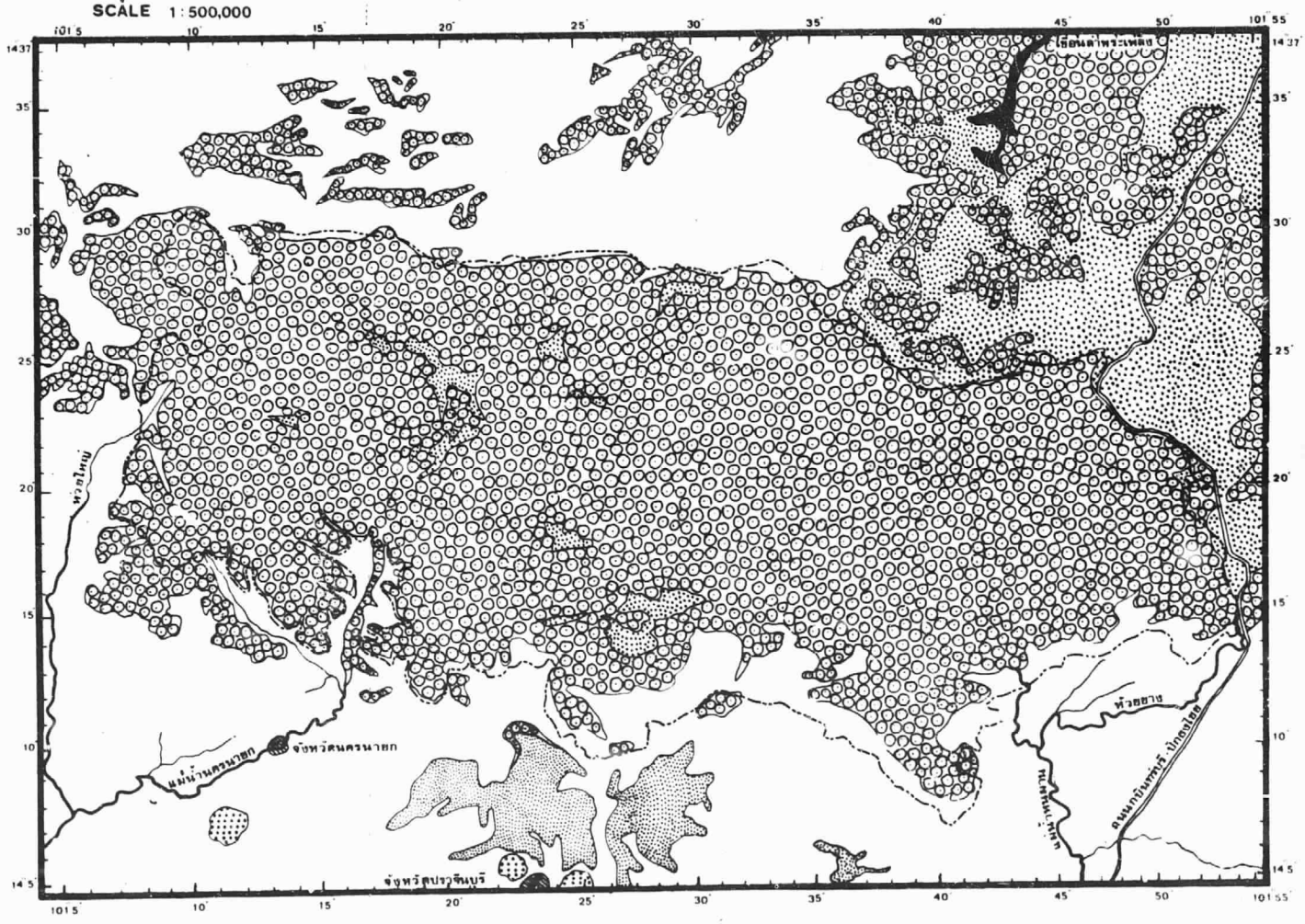
Compiled by Suthep Laohadet & Sathit Wacharakitti

แผนที่แสดงการใช้ที่ดินบริเวณอุทยานแห่งชาติเขาใหญ่ ปี 2516

FOREST AND AGRICULTURAL LAND USE MAP OF KHAO YAI NATIONAL PARK IN 1973

N

SCALE 1 : 500,000



Interpreted from Landsat image by visual interpretation using black & white prints of band 5 and band 7 and false color composites of band 4, 5 and 7 taken on January 6, 1973, NASA ID: E-1167-03063 at scale of 1: 250,000. Topographic map of 1: 250,000 scale of the year 1972 and map showing Khao Yai National Park boundary of the Royal Forestry Department at scale of 1: 250,000 of the year 1962 were used as base maps.

Compiled by Suthep Laohadet
&
Sathit Wacharakitti

เครื่องหมายแผนที่ (LEGEND)

- ตัวเมือง และสิ่งปลูกสร้าง (Urban and built-up land)
- ป่าไม้ (Forest land)
- ทุ่งหญ้า (Savannah)
- นาข้าว (Paddy field)
- พืชสวน (Horticultural land)
- สวนผลไม้ (Orchard)
- แหล่งน้ำ (Water resource)
- ถนน (Road)
- แนวเขตอุทยานแห่งชาติ (National park boundary
- แม่น้ำ และ ห้วย (River and stream)
- ★ จังหวัด (Changwat)

The Study of Land Use and Forest in Northeast Thailand from ERTS-1 Imagery Generated by IBM

Reported by

Krongsin Boonbocchara

Working Unit, Thailand National Remote Sensing Program

ABSTRACT

The study of land use and forest in northeast Thailand from ERTS-1 imagery generated by IBM computer has many purposes of surveying the natural resources to obtain a detailed information. This type of data is more advantageous than other forms of data hitherto available. The result of the study will be beneficial to the development planning of the country, especially in forestry since the forest is being depleted at an alarming rate.

Ground truth data collection was carried out first by determining sample points of tonal differentiations on the imagery. One hundred and three points were recorded. The ground truth survey was carried out to obtain the fact on the ground for those points. A map resulting from the interpretation and ground truth survey was then prepared to show the land use and forest in the whole ERTS frame for the benefits of the technologists and scientists and decision makers.

I. Introduction

Thailand National Remote Sensing Program (TNRSP) of the National Research Council is aimed at introducing the new data gathered by the Earth Resources Technology Satellite or Landsat for resources survey and planning of the country. The standard type of data normally used by the investigators is either a black and white print or a diazochrome transparency. However, recently TNRSP received through the World Bank a color composite print at approximately 1:500,000 scale and made directly from the CCT by IBM Company. It covers part of Northeast of Thailand and was taken on October 25, 1972 with NASA ID E-1094-03000 (THAILAND ID 721025-3-4). It seems to give more details than any other kind of imagery hitherto available because of better color rendition and richness in tone which enables the users to clearly identify land use and forest patterns, as well as reservoirs, rivers and urban area. It is therefore useful to conduct a study to access the advantages of such kind of data and also to make a general land use map based on this type of imagery.

II. Objectives

Thailand National Remote Sensing Program cooperates with the Department of Land Development and the Department of Forestry in this study. The overall objective is to find out the characteristics of various colors or tones appearing on the imagery which characterize the various land uses and forest patterns. The ultimate aim is to calculate the areas of various land use units, the forested areas; to identify forest types -

to apply the data in the watershed management, wild animal preservation as well as locating forest areas destroyed by illicit timber cutting. This imagery can accurately provide us the above details at a relatively short time and with less expenses.

III. Instruments and Equipment Used in Ground Truth Survey

1. ERTS-1 color composite print generated directly from CCT by IBM Company, taken on October 25, 1972 with NASA ID E-1094-03000 (Thailand ID 721025-3-4) at scale of 1:500,000

2. All 4 bands of ERTS-1 black and white prints taken on October 25, 1972 with NASA ID E-1094-03000 (Thailand ID 721025-3-4) at scale of 1:500,000.

3. The map sheet NE 48-9, NE 48-13, NE 48-10, NE 48-14, serial No. 1501, produced by Royal Thai Survey Department, at scale of 1:250,000.

4. The overlay sheet map reduced from map at scale of 1:250,000 to a scale of 1:500,000.

5. Diazochrome transparency of the same area at scale of 1:1,000,000.

6. 35 mm. camera for taking ground truth pictures, with color and black and white negatives; slides and infrared film.

7. Compass

8. Binoculars

9. Stationery

10. Ground truth record sheets

11. Two cars

IV. Procedures

1. Office work

The area under study as covered by the frame lies in the Provinces of Khon Kaen, Udon Thani, Sakon Nakhon, Kalasin and Mahasarakharm. Test sites were selected in these provinces because the percentage of cloud cover is very low at the time when the satellite was taking the imagery, therefore we can study several disciplines at the same time. The work of this study was coordinated through the Working Sub-Committee on Agriculture, Forestry and Land use of the National Committee for Coordinating the Remote Sensing Program to ensure inputs from concerned departments such as the Land Development Department and the Royal Forestry Department.

2. Field work

After the necessary preparations in the office, the ground truth

survey was conducted from September 16 to October 1, 1975 by checking all the 103 sampling plots in the provinces of Khon Kaen, Udon Thani, Sakon Nakhon, Kalasin and Mahasarakharm. All detailed information were recorded in the form provided and photographs were taken of the study areas using color and black & white negatives, slides and infrared film. These photos were to be used in conjunction with the imagery.

V. Results of the Study

The study of imagery and analysis using ground truth data, it is evident that:

(1) For land use, the color or tone as seen in this particular frame produced directly from CCT showed the following:

Blue = water area or inundated area
Green = farm crops for example rice
White = bare soil or area preparing for cultivation
Light red mixed with white = cultivating area such as those of cassava and jute

(2) For forestry, the color or tone can be identified as follows:

Dark red = Evergreen forest or deciduous forest
Light red or orange = Dipterocarp forest

With data provided by ground truth survey, comparison between the interpretation result and the ground truth is listed in Table 1.

Table 1

Interpretation Result versus Ground Truth

Plot No.	Color or tone	Interpretation result	Ground truth
1	dark red	forest	Evergreen forest of approximately 95-100% of total area.
2	light red & white	forest and farm crops	Dipterocarp forest, farm crops and area preparing for cultivation
3	light red & white	forest and farm crops	Dipterocarp forest, farm crops and area preparing for cultivation
4	light red	forest	Dipterocarp forest

Plot No.	Color or tone	Interpretation results	Ground truth
5	green & light red	rice field mixed with forest	rice field mixed with Dipterocarp forest
6	green & blue	inundated rice field	inundated rice field
7	light red & white	forest and bare soil	Dipterocarp forest and bare soil
8	green & light red	rice field and forest	rice field mixed with Dipterocarp forest
9	white & light red	farm crops cultivating area	farm crops cultivating area and Dipterocarp forest
10	white & light red	farm crops cultivating area	farm crops cultivating area and Dipterocarp forest
11	green & blue & light red	rice field mixed with forest	inundated rice field mixed with Dipterocarp forest
12	green & blue & light red	rice field mixed with forest	inundated rice field mixed with Dipterocarp forest
13	white & light red	bare soil	farm crops cultivating area
14	light red	forest	Dipterocarp forest
15	green & blue & light red	rice field mixed with forest	inundated rice field mixed with Dipterocarp forest
16	light red	forest	Dipterocarp forest
17	light red	forest	Dipterocarp forest
18	white & green	bare soil & rice field	bare soil and rice field
19	white	bare soil	bare soil
20	light red	forest	Dipterocarp forest
21	light red & white	farm crops cultivating area	jute cultivating area
22	dark red	forest	Deciduous forest
23	green & blue & white	rice field and bare soil	rice field and bare soil
24	green & blue & light red	rice field and forest	inundated rice field and Dipterocarp forest

Plot No.	Color or tone	Interpretation Result	Ground truth
25	green & blue & light red	rice field and forest	inundated rice field and Dipterocarp forest
26	light red	forest	Dipterocarp forest
27	light red	forest	Dipterocarp forest
28	light red & white	forest and bare soil	area preparing for farm crops cultivation
29	light red & white	forest and bare soil	Dipterocarp forest and bare soil
30	green & blue & light red	rice field and forest	inundated rice field and Dipterocarp forest
31	green & light red & white	rice field and forest	rice field and Dipterocarp forest
32	blue	water	reservoir
33	light red & white	forest and bare soil	Dipterocarp forest and bare soil
34	light red & blue	forest and reservoir	Dipterocarp forest and reservoir
35	white & light red	bare soil and forest	farm crop cultivating area and Dipterocarp forest
36	green & blue	rice field	inundated rice field
37	green & blue	rice field	rice field and inundated grassland
38	white & light red	farm crops cultivating area	farm crops cultivating area
39	green & blue & light red	rice field and forest	inundated rice field and Dipterocarp forest
40	light red & white	forest and bare soil	Dipterocarp forest and farm crop cultivating area
41	white & light red	bare soil and forest	bare soil and Dipterocarp forest

Plot No.	Color or tone	Interpretation result	Ground truth
42	light red & white	forest and bare soil	Dipterocarp forest and bare soil
43	dark red & white	forest and bare soil	Deciduous forest and farm crops cultivating area
44	green & blue & white	rice field and bare soil	inundated rice field and bare sandy soil
45	white & light red	bare soil and forest	farm crops cultivating area and Dipterocarp forest
46	green & blue & light red	rice field and forest	inundated rice field and Dipterocarp forest
47	green & blue	rice field	inundated rice field
48	green & blue & light red	rice field and forest	inundated rice field and Dipterocarp forest
49	green & blue & white	rice field and bare soil	inundated rice field and bare sandy soil
50	green & blue	rice field	inundated rice field (throughout a year)
51	green & blue & white	rice field & bare soil	rice field and inundated grassland and bare soil
52	white & light red	bare soil and forest	farm crops cultivating area and Dipterocarp forest
53	green & blue	rice field	rice field and inundated grassland
54	light red & green & blue	forest and rice field	Dipterocarp forest and inundated rice field
55	light red	forest	Dipterocarp forest
56	light red & white	forest and bare soil	Dipterocarp forest and bare soil
57	white & light red	bare soil and forest	bare soil and Dipterocarp forest
58	light red & white	forest and bare soil	Dipterocarp forest and bare soil

Plot No.	Color or tone	Interpretation result	Ground truth
59	light red & white	forest and bare soil	Dipterocarp forest and farm crops cultivating area
60	green & blue & light red	rice field and forest	rice field and Dipterocarp forest
61	light red & green & blue	forest and rice field	Dipterocarp forest and inundated rice field
62	green & light red	rice field and forest	rice field and Dipterocarp forest
63	light red	forest	Dipterocarp forest
64	light red	forest	Dipterocarp forest
65	*light red	forest	bare soil
66	green & light red	rice field and forest	rice field and Dipterocarp forest
67	white & light red	bare soil and forest	bare soil and Dipterocarp forest
68	green & blue & light red	rice field and forest	rice field and Dipterocarp forest
69	green & light red	rice field and forest	rice field and Dipterocarp forest
70	green & light red	rice field and forest	rice field and Dipterocarp forest
71	blue	inundated area	reservoir
72	light red & white	forest and bare soil	Dipterocarp forest and bare soil
73	dark red	forest	Mixed Deciduous forest
74	dark red	forest	Mixed Deciduous forest
75	light red & blue	forest and water area	Dipterocarp forest and inundated area
76	blue	reservoir	reservoir
77	light red & green	forest and rice field	Dipterocarp forest and rice field

Plot No	Color or tone	Interpretation result	Ground truth
78	light red	forest	Dipterocarp forest
79	light red	forest	Dipterocarp forest
80	light red & blue	forest and water area	Dipterocarp forest and reservoir
81	dark red	forest	Mixed Deciduous forest
82	dark red	forest	Evergreen forest
83	green & blue & light	rice field and forest	rice field mixed with Dipterocarp forest
84	light red	forest	Dipterocarp forest
85	*light red	forest	farm crops cultivating area and Dipterocarp forest
86	*light red	forest	farm crops cultivating area
87	light red	forest	Dipterocarp forest
88	green & blue & light red	rice field mixed with forest	inundated rice field mixed with Dipterocarp forest
89	white & light red	bare soil and forest	farm crops cultivating area and Dipterocarp forest
90	green & light red	rice field mixed with forest	rice field mixed with Dipterocarp forest
91	white & light red	bare soil and forest	farm crops cultivating area and Dipterocarp forest
92	white & light red	bare soil and forest	farm crops cultivating area and Dipterocarp forest
93	white	bare soil	farm crops cultivating area
94	light red	forest	Dipterocarp forest
95	light red	forest	Dipterocarp forest
96	light red & white	forest and bare soil	Dipterocarp forest and bare soil
97	dark red & blue	forest and water area	Mixed Deciduous forest and reservoir

Plot No.	Color or tone	Interpretation result	Ground truth
98	light red	forest	Dipterocarp forest
99	white & light red	bare soil and forest	farm crops cultivating area and Dipterocarp forest
100	green & light red	rice field and forest	rice field and Dipterocarp forest
101	dark red	forest	Mixed Deciduous forest
102	green & light red	rice field and forest	rice field and Dipterocarp forest
103	white	farm crops cultivating area	farm crops cultivating area

Remarks * refers to sampling plots for which the results of ground truth survey do not coincide with the interpretation.

VI. Results and discussions

We are able to make a key for ERTS-1 imagery interpretation for this frame as follows:

Blue	=	water area or inundated area
Green	=	farm crops (rice)
White	=	bare soil or area preparing for farm crops cultivation
Dark red	=	Evergreen forest or Mixed Deciduous forest
Light red	=	Dipterocarp forest

The results of ground truth survey are very satisfactory and they correspond to an accuracy of 98 %. Only 3 sampling plots were interpreted wrongly from among 103 sampling plots. Even the wrongly interpreted points may be accurately interpreted if ground truth was collected at the time of satellite overpass. The reason why the results of imagery interpretation came out more accurate than any other type of imagery is because the characteristics of various colors or tones can be seen clearly. Even the color or tone of the small area can also be seen. However, this type of imagery cannot classify various types of cultivation and type of forest. It can only differentiate between cultivated area and forest. For the forest, the color of forest enables us to know only two types of forest, that is, Dipterocarp forest and Evergreen forest, the latter is similar to the Mixed Deciduous forest.

Moreover, the reason why some interpretations were different from those of ground truth survey is that this imagery was taken in 1972 but ground truth survey was conducted in 1975. It is possible that the interpretation is correct for light red color should be interpreted as the forest. But when we went to check the ground truth, that particular forest was already cut down and became farm crops cultivating areas of sugar cane, cassava and jute.

Although the imagery produced directly from CCT as the one studied here is very useful in interpretation to level 1 and some catagories to level 2, the advantages can only be justified if the price of such imagery is reasonable. It was said that this imagery cost around 2,000 U.S. dollars to prepare one. The price would be acceptable if it only cost a few hundred dollars. Moreover, the usefulness of the imagery would be much enhanced if an interpretative analysis system is available to make more detail study.

The expenses of the ground truth survey are approximately US $600 for a team of 3 persons and 3.5 man-months for surveying. The office work took another 1.5 man-months. The total input is therefore 5 man-months and US $600 excluding the cost of imagery.

The data obtained from ground truth survey were used to produce a generalized land use map for the whole frame (Fig. 4) which can be used as the base map for various governmental and private projects.

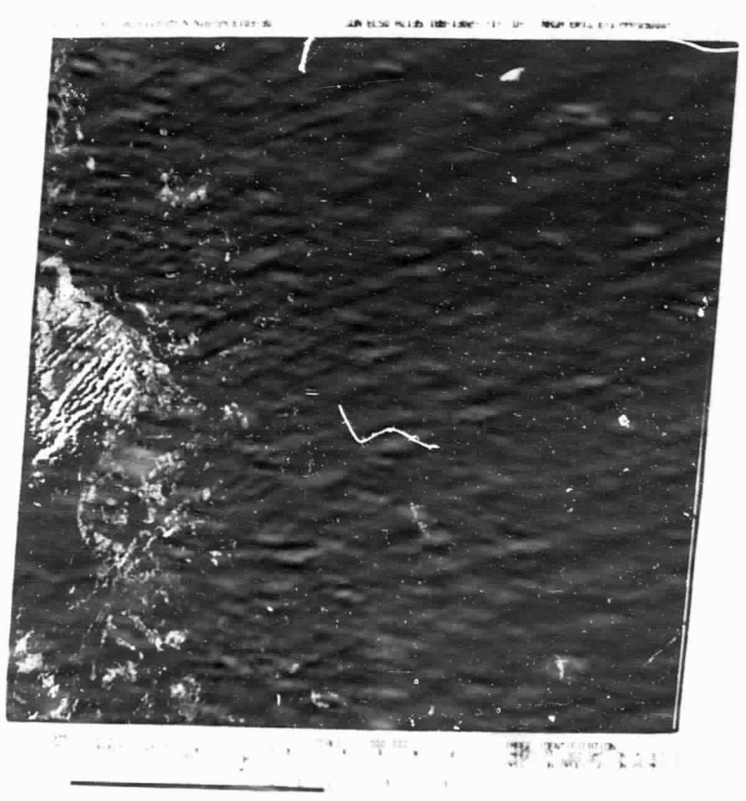


Fig. 1: ERTS-1 image which was generated directly from computer compatible tape.

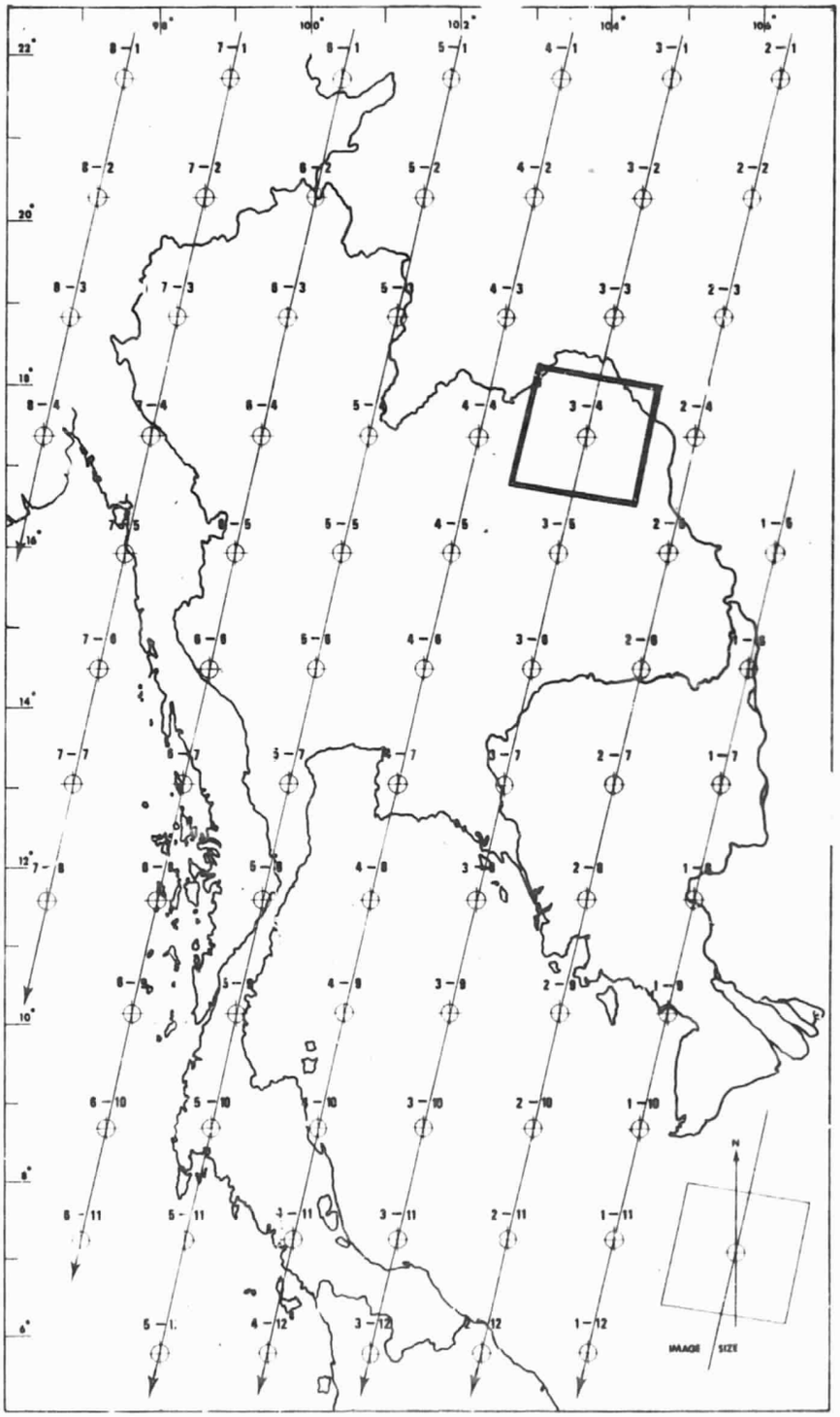


Fig. 2: Test Site, NASA E-1094-03000 (Thailand ID 721025-3-4)

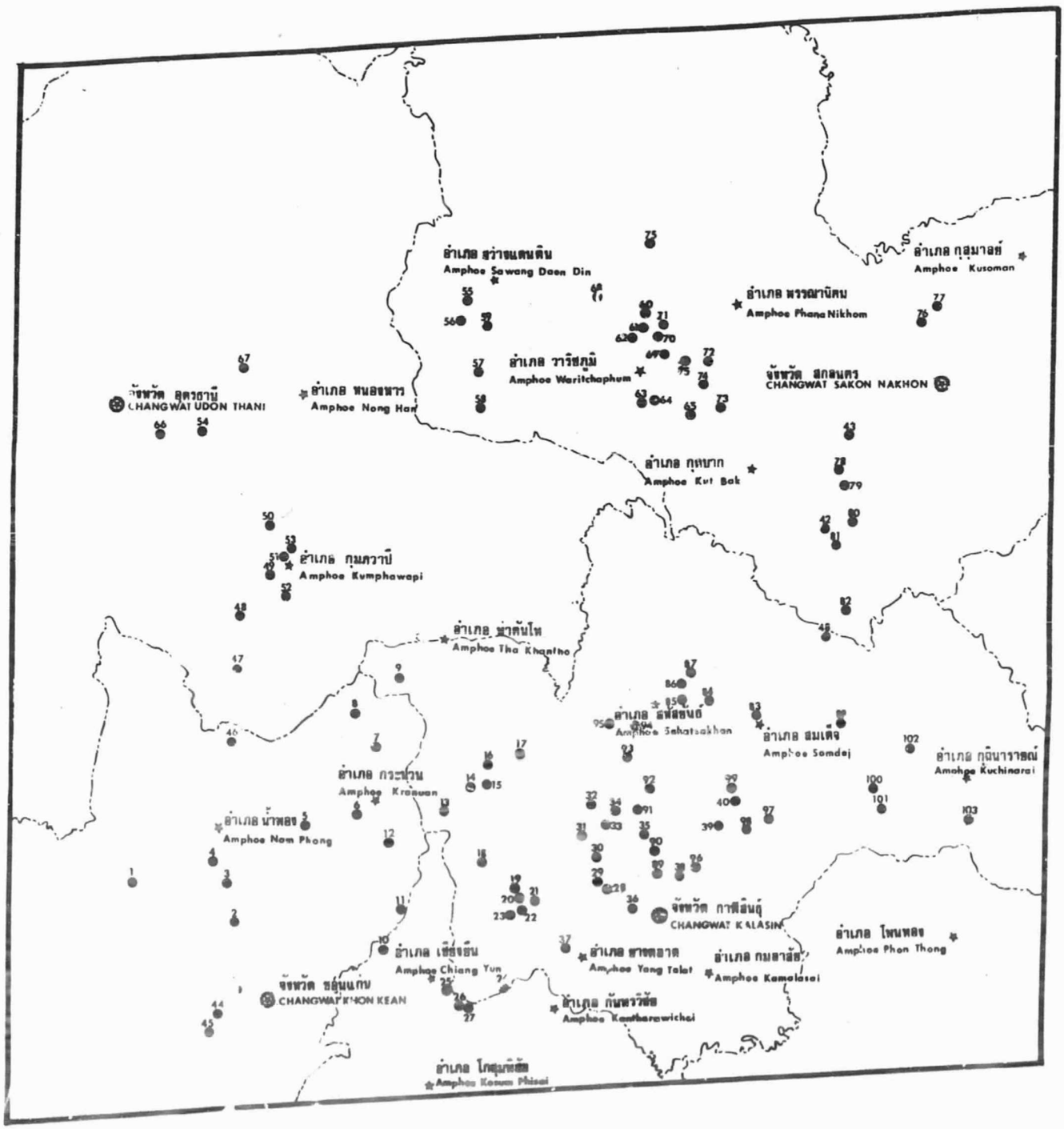
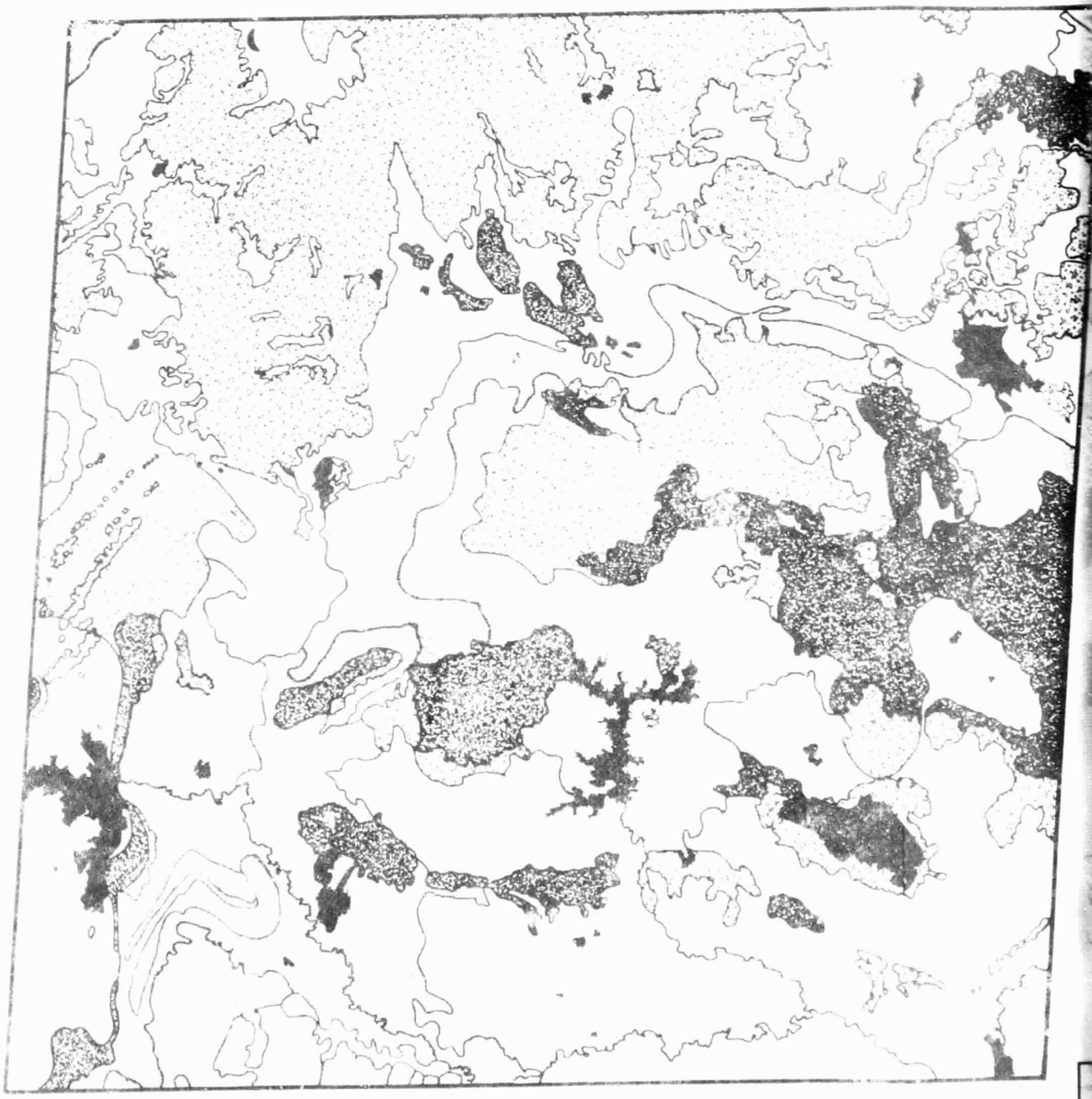


Fig. 3: Sampling points in Changwat Khon Kaen, Udon Thani, Sakon Nakhon, Kalasin and Maha Sarakham.

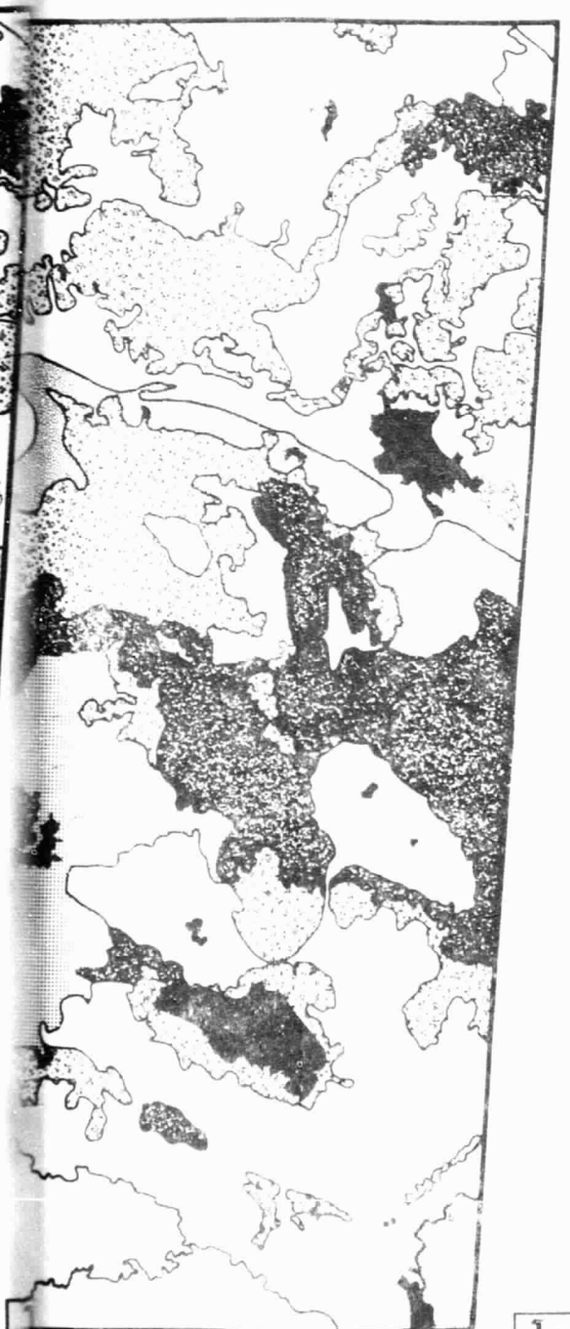
Fig. 4: Land use and forest map as interpreted from ERTS-1 image generated directly from computer compatible tape.

แผนที่แสดงการใช้ที่ดิน และป่าไม้จากภาพถ่ายป่
Map of Land Use and Forest Interpreted from Int



FOLDOUT FRAME

ะป่าไม้จากภาพถ่ายดาวเทียมฯ-๑ โดยใช้ไอบีเอ็มคอม
Interpreted from ERTS-1 Imagery Generated by IBM C



เครื่องหมาย
LEGEND

- อ่างเก็บน้ำ Reservoir
- นาข้าว Rice Field
- ป่าดงดิบ Evergreen Forest
- ป่าเต็งรังผสมนาข้าว Dipterocarp Forest mixed with Rice Field
- นาข้าวผสมป่าเต็งรัง Rice Field mixed with Dipterocarp Forest
- นาข้าว,พืชไร่ผสมป่าเต็งรัง Rice Field,Crops mixed with Dipterocarp Forest
- สิ่งก่อสร้าง Construction
- แม่น้ำ Rivers
- เมฆ Cloud

N

มาตราส่วน
SCALE
0 5 10 20 30 40 50 KM
0 5 10 15 20 25 30 MILE

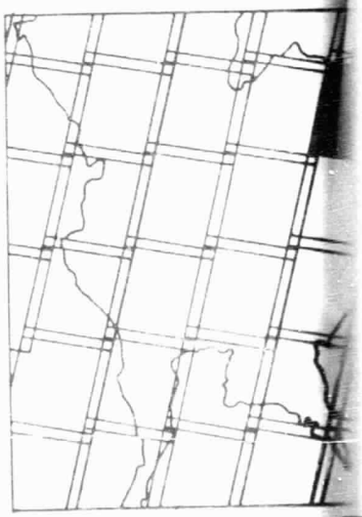


PHOTO INDEX
25 OCT. 197
E 1C94 0300

โครงการสำรวจทรัพยากรธรรมชาติด้วยดาวเทียม ฯ
THAILAND NATIONAL REMOTE SENSING PROGRAM
ธันวาคม ๑๘
DEC 75

FOLDOUT FRAME 2

FOLDOUT FRAME 3

ถ่ายดาวเทียมฯ-๑ โดยใช้ไอบีเอ็มคอมพิวเตอร์
m ERTS-1 Imagery Generated by IBM Computer

เครื่องหมาย
LEGEND

- อ่างเก็บน้ำ Reservoir
- นาข้าว Rice Field
- ป่าดงดิบ Evergreen Forest
- ป่าเต็งรังผสมนาข้าว Dipterocarp Forest mixed with Rice Field
- นาข้าวผสมป่าเต็งรัง Rice Field mixed with Dipterocarp Forest
- นาข้าว,พืชไร่ผสมป่าเต็งรัง Rice Field,Crops mixed with Dipterocarp Forest
- สิ่งก่อสร้าง Construction
- แม่น้ำ Rivers
- เมฆ Cloud

มาตราส่วน
SCALE
0 5 10 20 30 40 50 KM
0 5 10 15 20 25 30 MILE

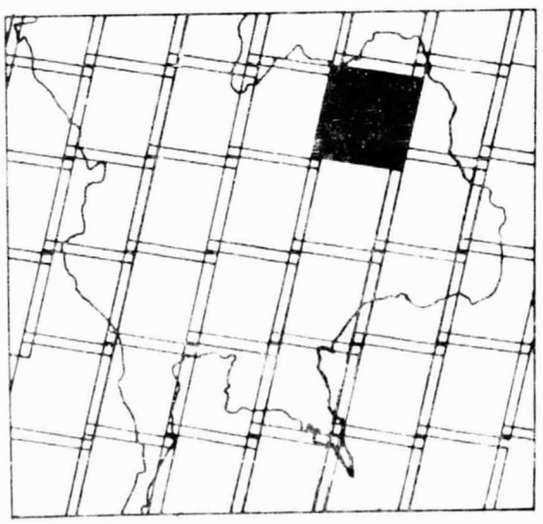


PHOTO INDEX
25 OCT 1972
E 1094 03000

โครงการสำรวจทรัพยากรธรรมชาติด้วยดาวเทียม ฯ
THAILAND NATIONAL REMOTE SENSING PROGRAM
ธันวาคม ๑๘
DEC 75

FOLDOUT FRAME 2

FOLDOUT FRAME 3

CODE

TYPE OF FOREST	CODE
Mixed Deciduous	10
Dry Dipterocarp	20
Tropical Evergreen	30
Pine Forest	40
Mangrove Forest	50
Bamboo Forest	60
Scrub	70

TYPE OF FOREST DISTURBANCES	CODE
Non-Disturbance	1
Cutting-Light	2
Cutting-Heavy	3
Fire Damage	4
Old clearing and Shifting Cultivation	5
Infestation	6

MACRORELIEF CLASSES	CODE
Flat Land	M1
Underiating and Rolling Land	M2
Hilly Land	M3
Mountatious Land	M4

CROWN DENSITY	CODE
75 - 100%	1
25 - 75%	2
0 - 25%	3

GROUND MOISTURE CONDITION	CODE
Wet	1
Medium	2
Dry	3
Very Dry	4

LEAF CONDITION (DECIDUOUS TREES)	CODE
Shedding	1
Spring	2
Flowering	3

ERTS-1 PROGRAM

FOREST GROUND INFORMATION DATA SHEET

ERTS-1 INFORMATION

LOCATION Amphoe: Kra-Nuan CHANGWAT Khon Kean

ORBIT No. ..... MSS BAND ..... SCALE .....

DATE PHOTO ..... LAT ..... LONG .....

FIELD PHOTOGRAPHY

LOCATION Ban Nong-Kung-Yai

TYPE OF FLIM Kodak Color

TIME .....

DATE Sept. 18, 75

LAND USE CATEGORY		
FORESTED AREA	01	~~01~~
CULTIVATED AREA	02	~~02~~
URBAN AREA	03	
WATER AREA	04	
DETERIORATED AREA	05	

SAMPLING PLOT No. 12

SIZE OF PLOT .... X ..... M

ELEVATION ..... M

SLOPE .....

ASPECT .....

TYPE OF FOREST	10	~~20~~	30	40	50	60	70
FOREST DISTURBANCES	~~1~~	2	3	4	5	6	
CROWN DENSITY	1	2	~~3~~				
LEAF CONDITION	~~1~~	2	3	DECIOUOUS TREE			

DOMINANT TREE Dipterocarpus alatus Roxb.

HEIGHT ..... M GIRTH ..... M

MACRORELIEF ..... M 1

GROUND MOISTURE CONDITION 1

No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M
1	Shorea obtusa Wall.		
2	Dipterocarpus tuberculatus		
3	Roxb.		
4			
5			
6			

No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M
7			
8			
9			
10			
11			
12			

REMARK Paddy 25-65% surrounded with Dipterocarp Forest

ERTS-1 PROGRAM

FOREST GROUND INFORMATION DATA SHEET

ERTS-1 INFORMATION

LOCATION Amphoe: Waritchaphum CHANGWAT Sakon Nakhon

ORBIT No..... MSS BAND..... SCALE.....

DATE PHOTO ..... LAT..... LONG.....

FIELD PHOTOGRAPHY

LOCATION Nam Oun Dam	LAND USE CATEGORY		SAMPLING PLOT No. 71
	FORESTED AREA	~~01~~	SIZE OF PLOT X M
TYPE OF FLIM Kodak Color	CULTIVATED AREA	~~02~~	ELEVATION M
TIME	URBAN AREA	03	SLOPE
DATE Sept. 25, 75	WATER AREA	04	ASPECT
	DETERIORATED AREA	05	

TYPE OF FOREST	10	20	30	40	50	60	~~70~~	DOMINANT TREE None
FOREST DISTURBANCES	1	2	3	4	~~5~~	6		HEIGHT M GIRTH M
CROWN DENSITY	1	2	~~3~~					MACRORELIEF M 1
LEAF CONDITION	~~1~~	2	3	DECIOUOUS TREE				GROUND MOISTURE CONDITION 1

No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M	No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M
1				7			
2				8			
3				9			
4	None			10			
5				11			
6				12			

REMARK Water area, surrounded with Dipterocarp Forest and crops.

ERTS-1 PROGRAM

FOREST GROUND INFORMATION DATA SHEET

ERTS-1 INFORMATION

LOCATION Amphoe: Waritchaphum CHANGWAT Sakon Nakhon

ORBIT No. ..... MSS BAND ..... SCALE .....

DATE PHOTO ..... LAT ..... LONG .....

FIELD PHOTOGRAPHY

LOCATION Phu Phan National Forest

TYPE OF FLIM Kodak Color

TIME .....

DATE Sept. 26, 75

LAND USE CATEGORY		
FORESTED	AREA	01
CULTIVATED	AREA	02
URBAN	AREA	03
WATER	AREA	04
DETERIORATED	AREA	05

SAMPLING PLOT No. 73

SIZE OF PLOT X M

ELEVATION ..... M

SLOPE .....

ASPECT .....

TYPE OF FOREST	10	20	30	40	50	60	70
FOREST DISTURBANCES	1	2	3	4	5	6	
CROWN DENSITY	1	2	3				
LEAF CONDITION	1	2	3	DECIOUOUS TREE			

DOMINANT TREE Afzelia xylocarpa Craib.

HEIGHT ..... M GIRTH ..... M

MACRORELIEF ..... M 4

GROUND MOISTURE CONDITION 2

No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M
1	Xylia Kerii Craib		
2	Vitex spp.		
3	Hopea odorata Roxb.		
4			
5			
6			

No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M
7			
8			
9			
10			
11			
12			

REMARK Mixed Deciduous Forest with dense understory regrowth.

ERTS-1 PROGRAM

FOREST GROUND INFORMATION DATA SHEET

ERTS-1 INFORMATION

LOCATION Amphoe: Sahatsakhan CHANGWAT Kalasin

ORBIT No..... MSS BAND..... SCALE.....

DATE PHOTO ..... LAT..... LONG.....

FIELD PHOTOGRAPHY

ORIGINAL PAGE IS
OF POOR QUALITY

LOCATION Ban Mong-Kun-Chon .....

TYPE OF FLIM Kodak Color

TIME .....

DATE Sept. 29, 75

LAND USE CATEGORY		
FORESTED	AREA	01
CULTIVATED	AREA	~~02~~
URBAN	AREA	03
WATER	AREA	04
DETERIORATED	AREA	05

SAMPLING PLOT No. 86

SIZE OF PLOT X M

ELEVATION ..... M

SLOPE .....

ASPECT .....

TYPE OF FOREST	10	20	30	40	50	60	70
FOREST DISTURBANCES	1	2	3	4	5	6	
CROWN DENSITY	1	2	3				
LEAF CONDITION	1	2	3	DECIOUOUS TREE			

DOMINANT TREE None

HEIGHT ..... M GIRTH ..... M

MACRORELIEF ..... M 1

GROUND MOISTURE CONDITION 2

No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M	No.	PROMINANT SPECIES	NO OF TREE	AVE HEIGHT M
1				7			
2				8			
3				9			
4	None			10			
5				11			
6				12			

REMARK Cassava Plantation 70-85% cover with scattered trees.

Application of Landsat Imagery in Geology

Reported by

Prayong Angsuwathana

Department of Mineral Resources

I. Introduction

The work described in this section was carried out in the Photo-geological Survey Laboratory of the Department of Mineral Resources. Ministry of Industry, by using photo-geological interpretation techniques applied to LANDSAT imagery. Black-and-white MSS band-7 images, which show some geologic features with high contrast, were used for most of the work. Features were plotted on Koda-Trace material taped over the transparencies on a light table, first working in the visible drainage patterns, dips, strikes, major structure and boundaries of rock types.

The area studied is in Phetchabun, Chaiyaphum and Khon Kaen provinces located in the North-Eastern part of Thailand; Eastern scene is on the plateau, Western scene is mountainous. Rock types present in the area are sedimentary and metamorphic. The oldest rock, of Carboniferous age, is exposed along the Western scene.

II. Procedures

The work was separated into four parts:

(a) Discrimination by consideration of drainage patterns, tonal-textural variations, and identification of structures, faults, fractures and folds;

(b) Several rock types were discriminated, considering physical properties and the known erosion rates of the various rock types, which reflect differences in geomorphology; studies of drainage patterns, surface roughness, type of erosion, tone of certain rock types, and vegetation types all contributed to identification. Dominant rock types, for examples: limestone, sandstone, shale, and some metamorphic rocks, were identified from the space imagery;

(c) Conventional aerial photography coverage of the same frame was available for comparison and classification;

(d) Field investigations were conducted after the laboratory work was terminated, to check the results of interpretation.

Reference to image and overlay (Fig. I)

Symbol 1 : This is the oldest rock in the studied area, forming

an anticlinorium axis in the Western scene around Phetchabun. The formation consists of slaty shale, and phillite, light grey limestone interbeded with shale, sandstone, mudstone, conglomerate and volcanic tuff.

Symbol 2 : Massive light grey limestone, interbeded with shale, sandstone, conglomerate.

Symbol 3 : Shale interbeded sandstone.

Symbol 4 : This formation is of low relief, consists of Micaceous shale with some siltstone, micaceous sandstone and conglomerates.

Symbol 5 : Micaceous shale and micaceous siltstone.

Symbol 6 : Sandstone, shale and siltstone.

Symbol 7 : Residual soil, valley fill, gravel.

Symbol 8 : Alluvium.

III. Structural Geology

The structure of the study area can be divided into two parts. Eastern area is Plateau, slightly tectonic, gentle dipping. Western area structure is strongly tectonic, steep dipping, striking to N.S., forming anticlinorium, many big faults can be observed which have never been mapped before, as well as folding in the Eastern area.

(Fig. 2) The structure of the study area is complex owing to many periods of tectonic movement, including igneous intrusion, anticlines and synclines up to anticlinorium and synclinorium were formed and there was considerable faulting, with movement of several kilometres. Several kinds of faults occur in this area, including normal faults, thrust faults, and wrench faults, resulting from tension and release pressure, average striking N.S. Big faults, fractures, and folds which had not been found before are visible in the imagery.

IV. Conclusion

The experience gained in using LANDSAT imagery may be summarized as follows:

(a) Each frame of the LANDSAT images covers an extensive area; therefore such large scale structures as anticlines, synclines etc., can be observed at once from one frame of an image. This creates a broad understanding of the geologic history of an area and enables the correlation of lithology through study of all the successive strata in the same frame. In aerial photography more work and many more aerial photographs are needed in order to achieve the same purpose. Furthermore, if an aerial photomosaic is used, different tones between air photos are often unavoidable, owing to the intermittent time between each aerial photograph.

It makes possible the exposure of an area of the north-eastern part of Thailand, the so-called "Korat Plateau". It covers an area of 10,000 km^2. The rock types can be recognized from LANDSAT images used in the preparation. Moreover, the folding such as anticlines and synclines, also can be seen from the same frame, as well as the lithology of the area.

(b) From LANDSAT imagery, geologic structures, especially fractures and faults, can be traced for long distances. If such a structure were to be traced from air photos, many photographs would be needed and certain drawbacks would yet remain: the structure might be dispersed sporadically, making photo-reconnaissance difficult; and the largeness of some circular features might necessitate many aerial photographs, thus masking the relationship between two rock types. But the LANDSAT image can differentiate features distinctly. With regard to lithology, it is difficult to classify owing to the small scale involved (1:1,000,000); however, rocks with individually prominent features, such as limestone, sandstone, quartzite and granite, can be analyzed.

(c) Enlargement of the LANDSAT image from 1:1,000,000 to 1:500,000 does not yield more detail, but it does help to facilitate study, to draw geological details and to determine the classification of rock type.

(d) In geological interpretation for map-making from LANDSAT images aerial photographs serve an essential function in comparative studies. They may also be employed in lithological analysis of the rocks of any area under study. Also, by means of mirror stereoscopy, rock varieties and their slips and strikes can be verified.

(e) "Ground truth" is also important for this project. It is essential in verifying and improving the results of interpretation of the area in question.

(f) Positive transparencies can yield more information than paper prints, by providing additional details in relief, tone, texture and geological feature. If the four bands are all obtained, the result of every band can contribute to the total investigation. Each band can give each feature in high contrast.

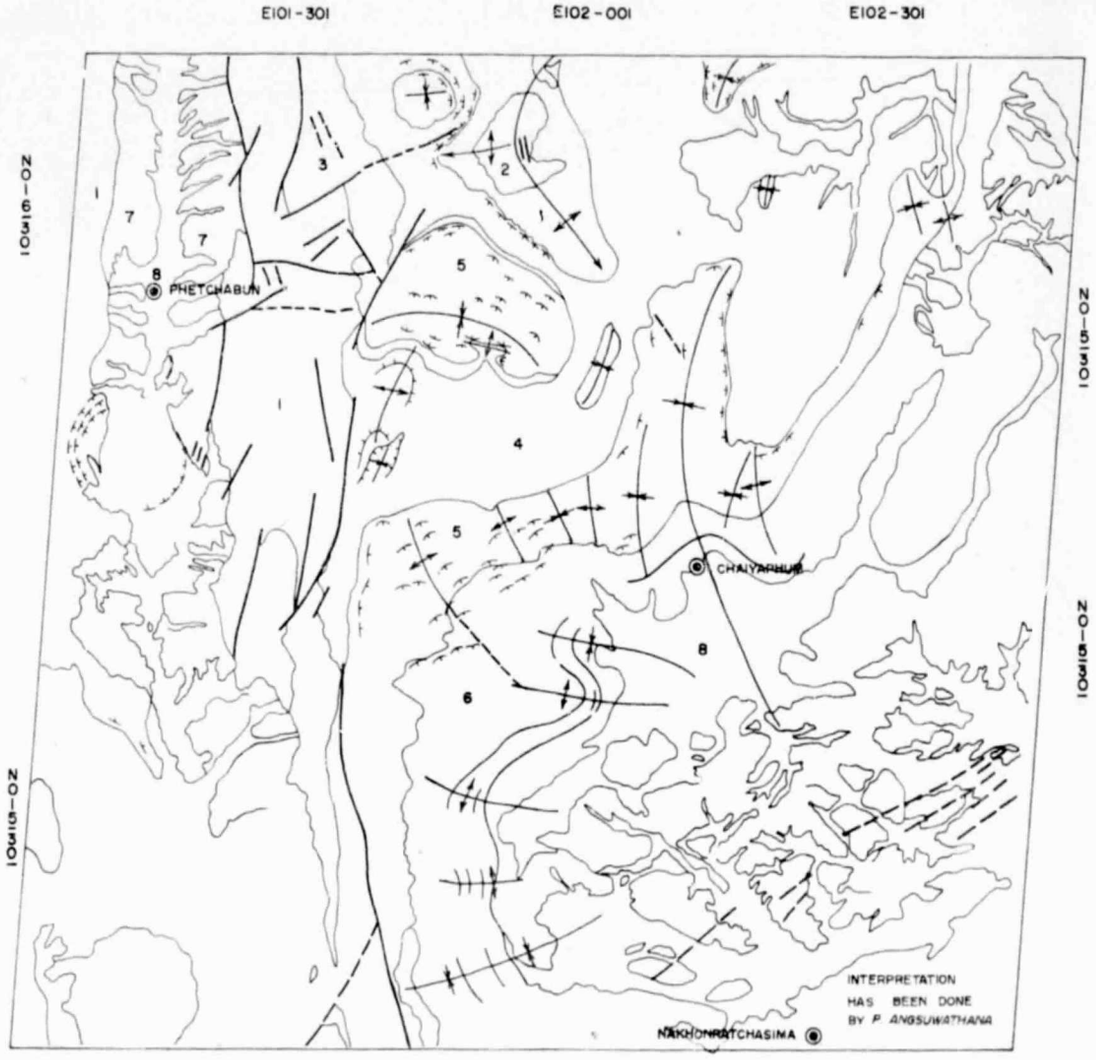


Fig. 1: Geologic structures of Northeast Thailand as interpreted from Landsat image.

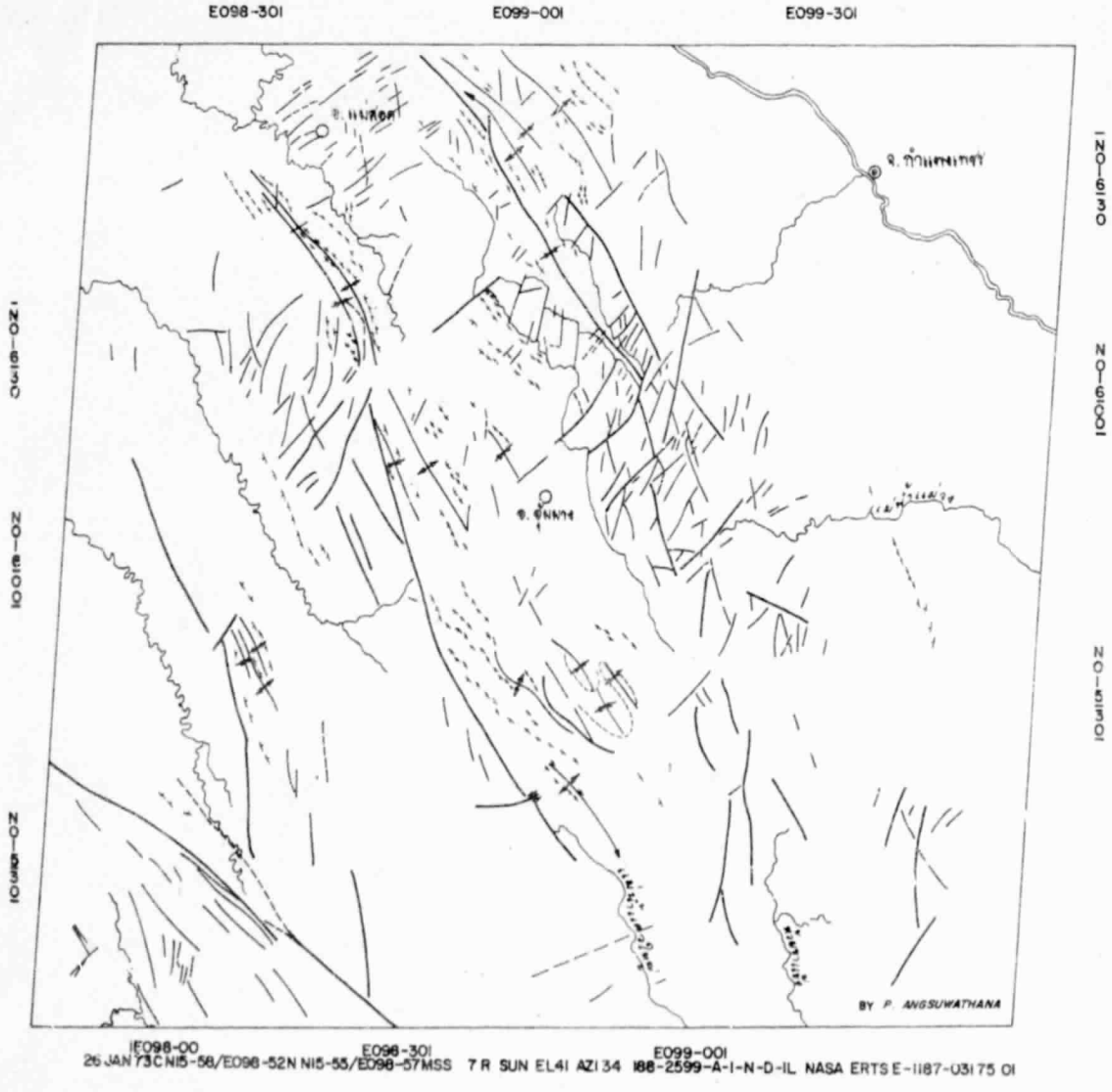


Fig. 2: Geologic structures of West Thailand as interpreted from Landsat image.

Fig. 3: Landsat image of Northeast Thailand which was interpreted for geologic structures shown in Fig. 1

obscured by clouds, only an area of 11,400 sq.km. was accessible for interpretation and out of this total area the flooded area was found to cover an area of 2,235 sq.km.

V. Discussion and Conclusion

It was found that most of the flooded lands were in the flooded plain of the Lower Chao Phraya Basin. The damaged areas consisted mostly of rice fields extending from both sides of the banks of the Chao Phraya River and its tributaries, such as Suphunburi River and Lopburi River. Especially the areas criss-crossed by network of irrigation canals were affected most extensively. However, damages to the agricultural crops were not too severe due to the fact that most of the farmers had harvested their crops. However, roads in Bangkok metropolitan area and orchards in the suburbs of Bangkok were greatly damaged. Road repair in Bangkok alone costed the administration several million dollars. The forecasting of such flooding might help minimize the cost. Major problem confronted in the study of satellite imagery is cloud cover. Therefore air-borne remote sensing might play a major role in monitoring and assessing the flooding which should be planned in the future.

Figure 1: Band 7 of LANDSAT data were compared between two different periods to show effect of flooding. The left scene was taken on November 8, 1975 which showed extend of major flooding (dark areas) in the Central Plain of Thailand. The right scene was taken on January 7, 1973 which depicted the normal stage of the same region.

MAP OF FLOODING IN CENTRAL P

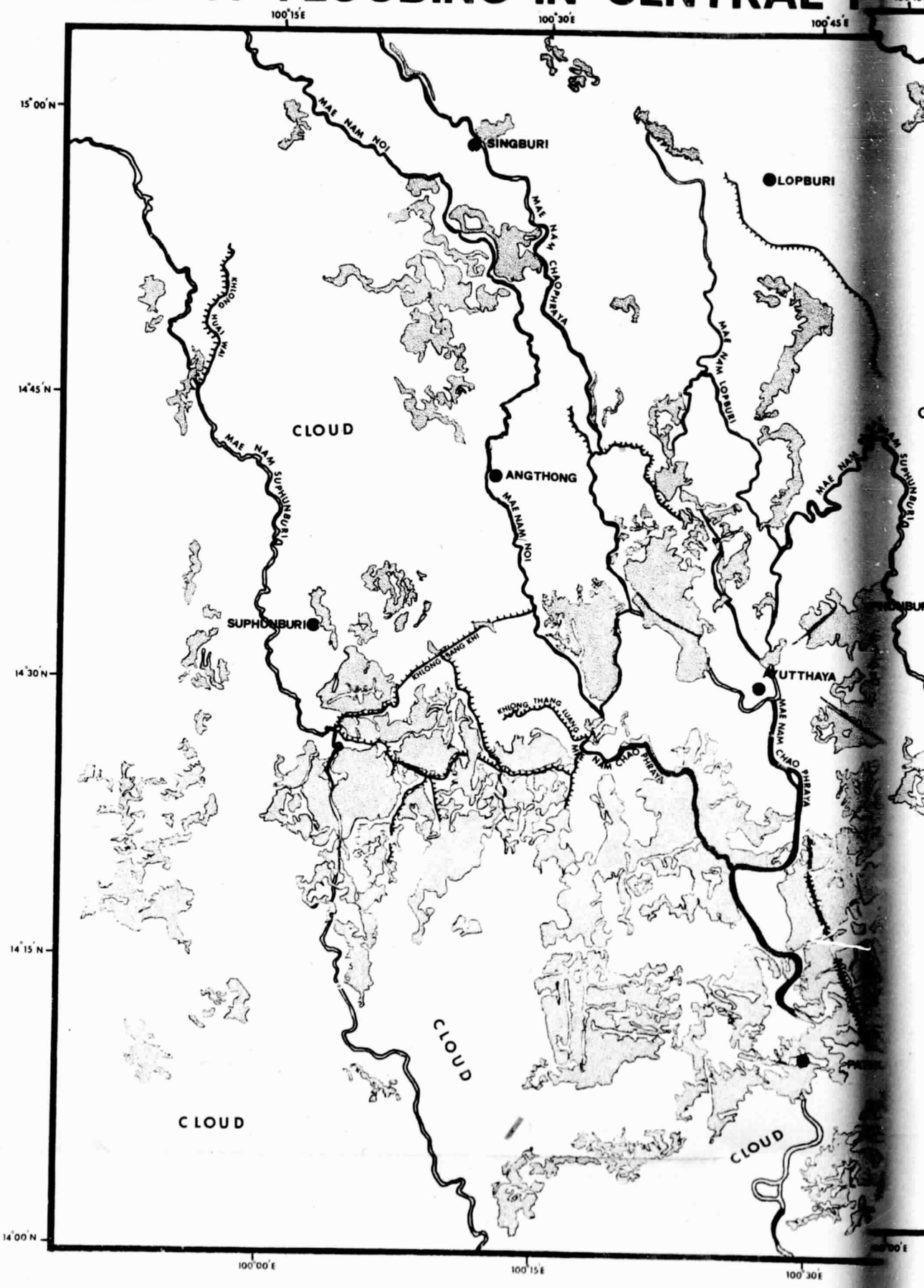
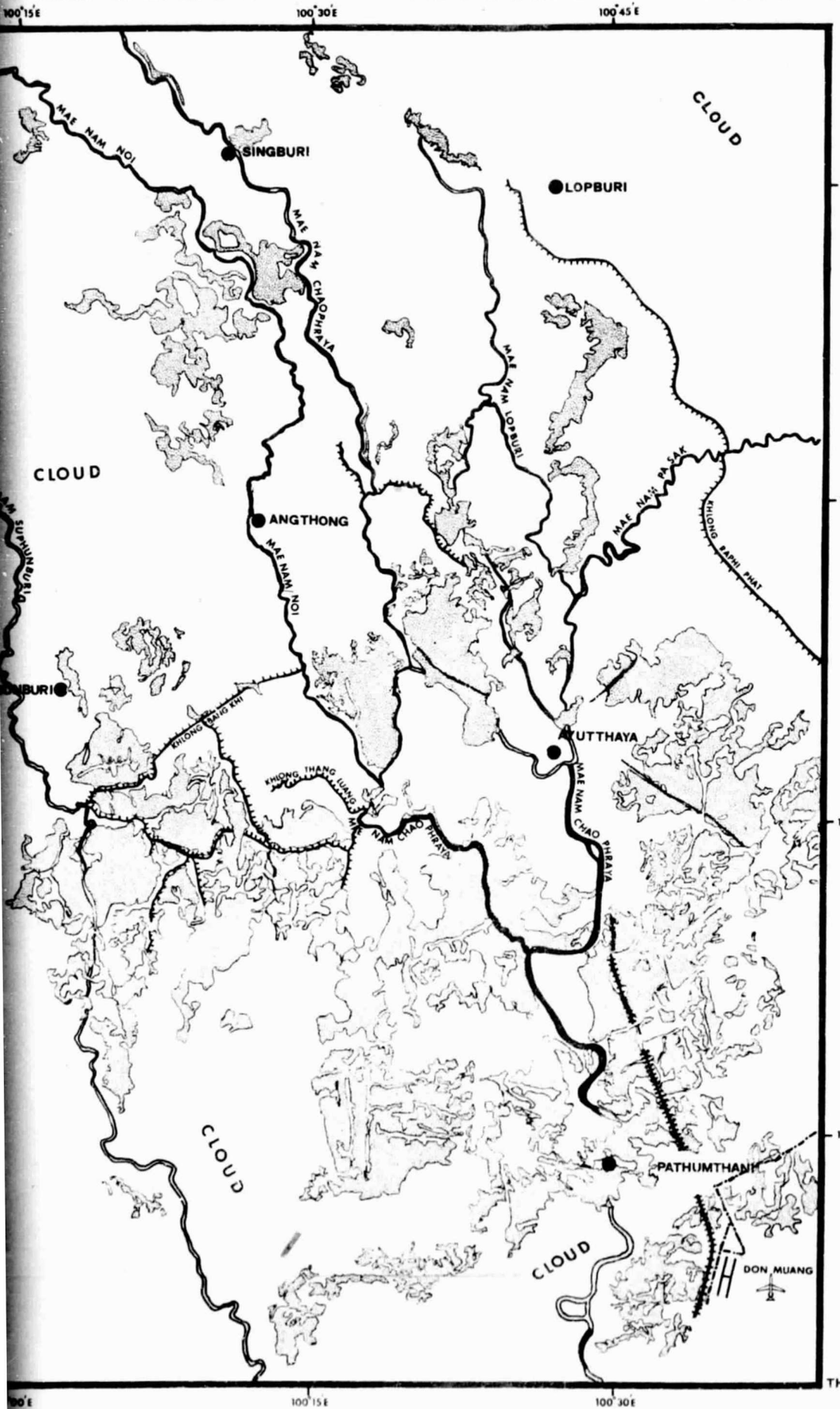


Figure 2: Map made from interpretation of LANDSAT imag
ing over large portion of Central Plain (Sing
Buri, Ang Thong, Phathum Thani, Ayutthaya a

FOLDOUT FRAME 1

FLOODING IN CENTRAL PLAIN OF THAILAND

NOVEMBER 1975



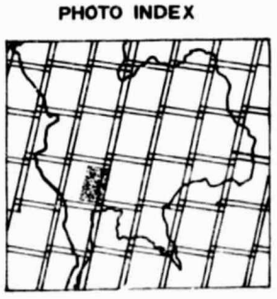
LEGEND

- PROVINCIAL CAPITAL
- AIRPORT
- RIVER (MAE NAM)
- CANAL (KHLONG)
- FLOODED AREA
- RAILROAD
- ROAD

INTERPRETED FROM LANDSAT-2 IMAGERY

THAI ID. 5-6 NASA E-2290-02590

PHOTO INDEX



8 NOVEMBER 1975

NASA ERTS-E 2290-02590

SCALE 1 : 500,000

5 0 5 10 KILOMETERS

NOTE:

WHITE PORTION ACTUAL RIVER OBSCUSED BY CLOUD

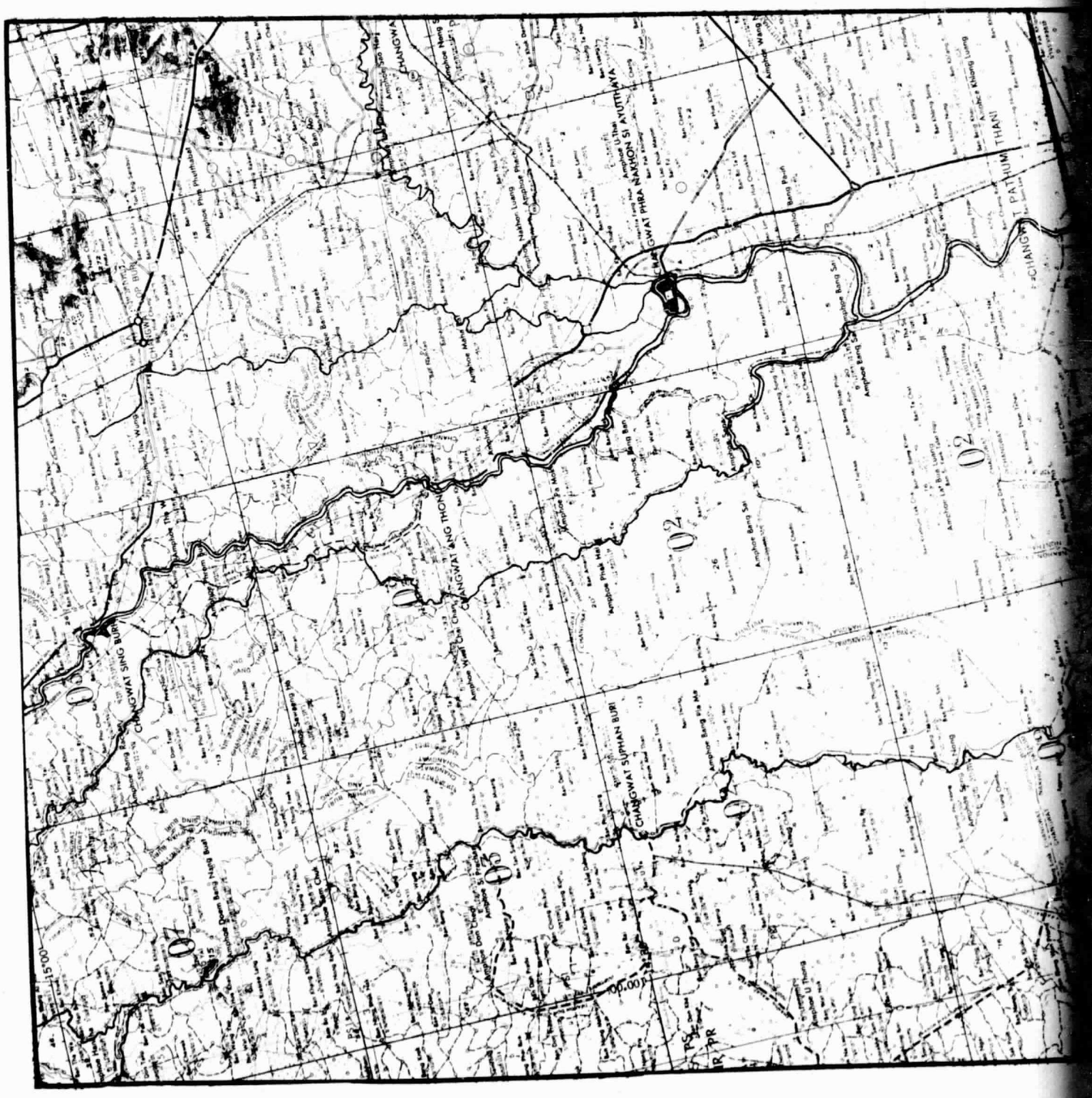
N

INTERPRETED AND PREPARED BY

THAILAND NATIONAL REMOTE SENSING PROGRAMME

Figure 2: Map made from interpretation of LANDSAT imagery showing extent of flooding over large portion of Central Plain (Sing Buri, Suphun Buri, Lop Buri, Ang Thong, Phathum Thani, Ayutthaya and Bangkok).

FOLDOUT FRAME 2



FOLDOUT FRAME 1

Figure 3: Topographic map of Central Plain showing the provincial towns, highways, roads, railway, rivers, canals and contour lines.

FOLDOUT FRAME 3

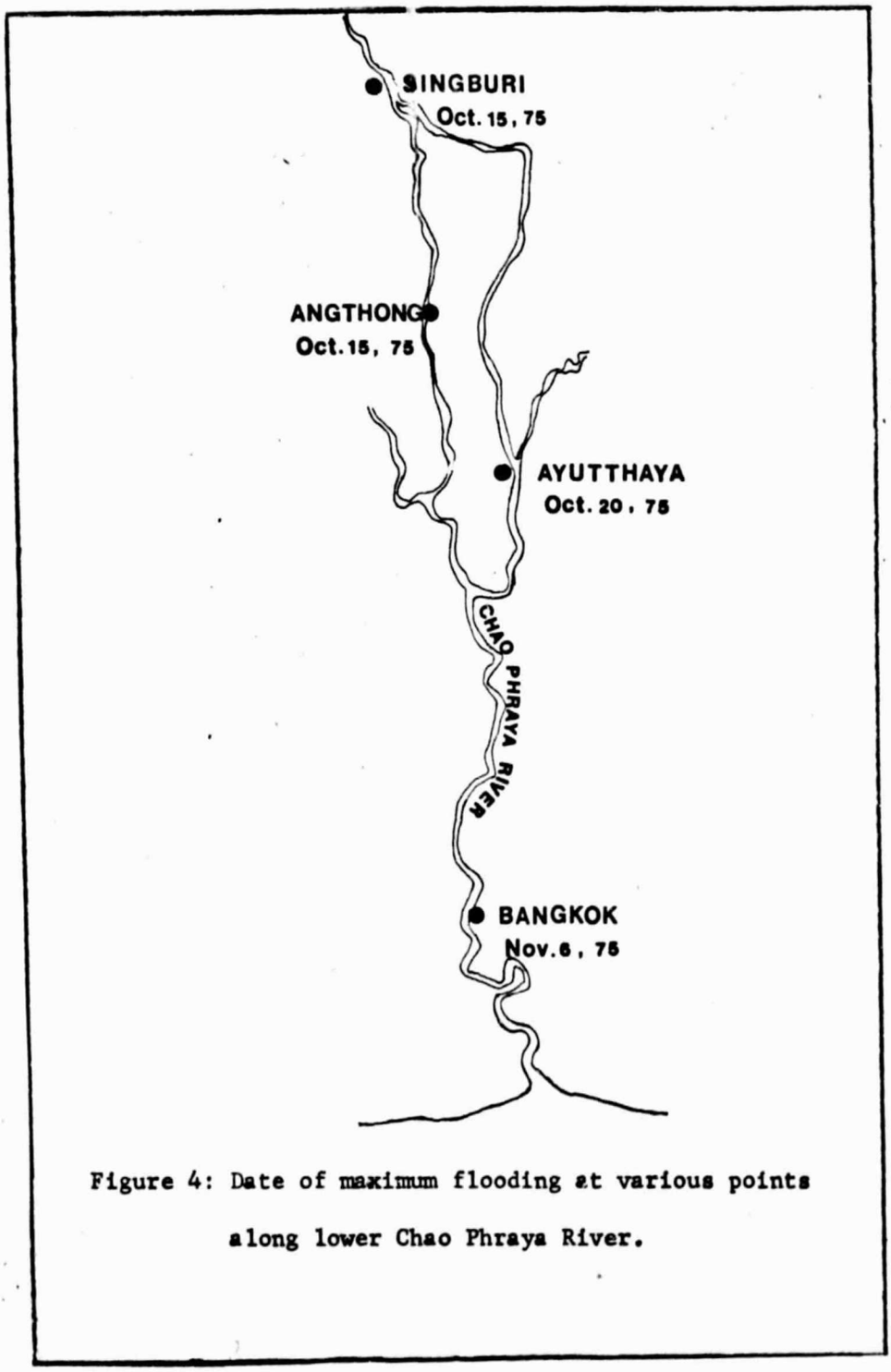


Figure 4: Date of maximum flooding at various points along lower Chao Phraya River.

Appendix

Data Products Received from EROS Data Center

The following are 70 m.m. Negative transparencies received from EROS Data Center since June, 1975 up to June 1976, under G28080.

1. Received on June 20, 1975; 6 scenes in duplicate totalling 46 frames:

Date	NASA ID	Thailand ID	% Cloud
5 APR 75	E-2073-02532	750405-4-2	60
"	E-2073-02534	3	10
"	E-2073-02541	4	10
"	E-2073-02543	5	30
"	E-2073-02550	6	70
"	E-2073-02552	7	50

2. Received on July 1, 1975: 2 scenes in duplicate totalling 16 frames:

Date	NASA ID	Thailand ID	% Cloud
27 MAY 75	E-2125-02452	750527-2-11	70
"	E-2125-02561	13	60

3. Received on July 16, 1975: 6 scenes in duplicate totalling 48 frames:

Date	NASA ID	Thailand ID	% Cloud
7 APR 75	E-2075-03042	750407-6-1	0
"	E-2075-03044	2	10
"	E-2075-03051	3	10
"	E-2075-03053	4	10
"	E-2075-03060	5	10
"	E-2075-03062	6	20

4. Received on July 17, 1975; 1 scene in duplicate totalling 8 frames:

Date	NASA ID	Thailand ID	% Cloud
25 APR 75	E-2093-03042	750425-6-1	10

5. Received on August 17, 1975; 10 scenes in duplicate totalling 80 frames:

Date	NASA ID	Thailand ID	% Cloud
5 JUL 75	E-2164-02593	750705-5-3	50
"	E-2164-025955	4	30
"	E-2164-03002	5	60
"	E-2164-03004	6	50
"	E-2164-03011	7	60
"	E-2164-03013	8	50

Date	NASA ID	Thailand ID	% Cloud
5 JUL 75	E-2164-03020	750705-5-9	50
"	E-2164-03022	10	30
"	E-2164-03025	11	30
"	E-2164-03031	12	40

6. Received on September 4, 1975; 10 scenes in duplicate totalling 80 frames:

Date	NASA ID	Thailand ID	% Cloud
4 JUL 75	E-2163-02534	750704-4-3	60
"	E-2163-02541	4	70
"	E-2163-02543	5	30
"	E-2163-02550	6	30
"	E-2163-02552	7	20
"	E-2163-02555	8	20
"	E-2163-02561	9	20
"	E-2163-02564	10	40
"	E-2163-02570	11	40
"	E-2163-02573	12	70

7. Received on September 9, 1975; 7 scenes in duplicate totalling 56 frames:

Date	NASA ID	Thailand ID	% Cloud
20 JUL 75	E-2179-02423	750720-2-4	50
"	E-2179-02434	7	70
"	E-2179-02441	8	50
"	E-2179-02450	10	50
"	E-2179-02452	11	60
"	E-2179-02455	12	70
"	E-2179-02461	13	60

8. Received on September 10, 1975; 12 scenes in duplicate totalling 96 frames:

Date	NASA ID	Thailand ID	% Cloud
3 JUL 75	E-2162-02491	750703-3-5	30
"	E-2162-02494	7	40
"	E-2162-02500	8	30
"	E-2162-02503	9	40
"	E-2162-02505	10	40
"	E-2162-02512	11	30
"	E-2162-02514	12	50
22 JUL 75	E-2181-02544	750722-4-6	70
"	E-2181-02551	7	70
"	E-2181-02553	8	60
"	E-2181-02560	9	60
"	E-2181-02565	11	50

9. Received on October 9, 1975; 4 scenes in duplicate totalling 32 frames:

Date	NASA ID	Thailand ID	% Cloud
23 JUL 75	E-2182-03002	750723-5-6	70
"	E-2182-03005	7	60
"	E-2182-03011	8	60
"	E-2182-03014	9	50

10. Received on November 4, 1975; 2 scenes in duplicate totalling 16 frames:

Date	NASA ID	Thailand ID	% Cloud
29 SEP 75	E-2250-02360	750929-1-5	60
30 SEP 75	E-2251-02412	750930-2-4	60

11. Received on December 17, 1975; 4 scenes in duplicate totalling 32 frames:

Date	NASA ID	Thailand ID	% Cloud
23 OCT 75	E-2274-03083	751023-7-1	70
"	E-2274-03090	2	70
"	E-2274-03092	3	70
"	E-2274-03095	4	70

12. Received on December 30, 1975; 11 scenes in duplicate totalling 88 frames:

Date	NASA ID	Thailand ID	% Cloud
20 OCT 75	E-2271-02515	751020-4-2	50
"	E-2271-02521	3	70
"	E-2271-02524	4	70
"	E-2271-02533	6	60
"	E-2271-02535	7	50
"	E-2271-02551	10	40
7 NOV 75	E-2289-02520	751107-4-3	80
"	E-2289-02534	7	90
8 NOV 75	E-2290-02574	751108-5-3	70
"	E-2290-02581	4	40
"	E-2290-02583	5	80

13. Received on January 20, 1976; 7 scenes in duplicate totalling 56 frames:

Date	NASA ID	Thailand ID	% Cloud
24 NOV 75	E-2306-02460	751124-3-3	20
"	E-2306-02463	4	10
"	E-2306-02465	5	10

Date	NASA ID	Thailand ID	% Cloud
24 NOV 75	E-2306-02472	751124-3-6	10
"	E-2306-02474	7	10
"	E-2306-02481	8	10
"	E-2306-02483	9	30

14. Received on May 24, 1976; 1 scene in duplicate totalling 6 frames;

Date	NASA ID	Thailand ID	% Cloud
19 MAR 75	E-2056-03020	750319-5-9	40

15. Received on June 22, 1976; 29 scenes in duplicate totalling 232 frames:

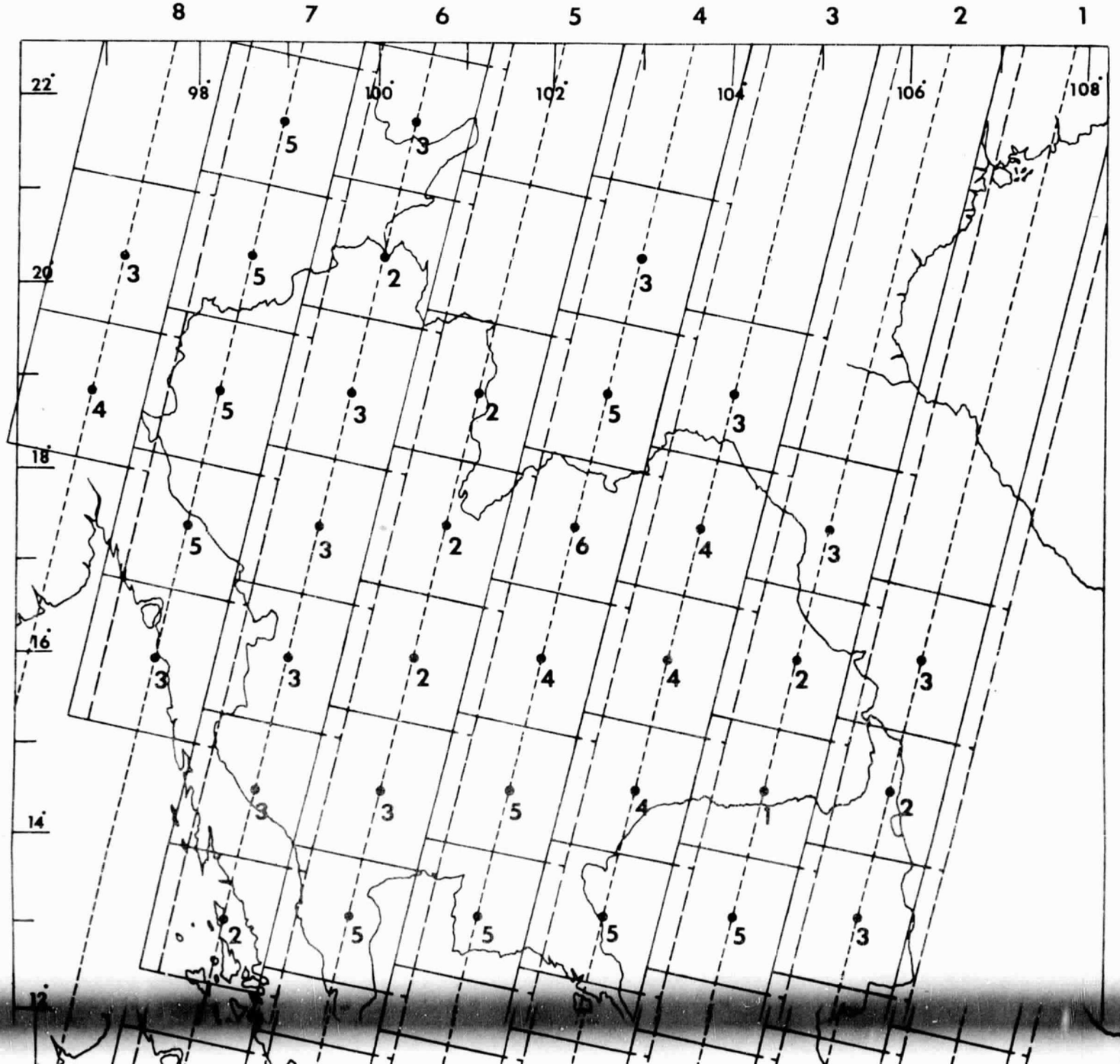
Date	NASA ID	Thailand ID	% Cloud
9 FEB 75	E-2018-02490	750209-3-5	60
"	E-2018-02493	6	40
11 FEB 75	E-2020-03012	750211-5-7	20
"	E-2020-03015	8	30
"	E-2020-03021	9	60
12 FEB 75	E-2021-03055	750212-6-4	30
"	E-2021-03062	5	10
"	E-2021-03064	6	10
"	E-2021-03071	7	10
13 FEB 75	E-2022-03114	750213-7-4	20
"	E-2022-03120	5	30
26 FEB 75	E-2035-02432	750226-2-6	10
27 FEB 75	E-2036-02490	750227-3-5	10
"	E-2036-02493	6	30
28 FEB 75	E-2039-02545	750228-4-5	40
2 MAR 75	E-2039-03055	750302-6-4	60
"	E-2039-03061	5	40
"	E-2039-03064	6	40
3 MAR 75	E-2040-03113	750303-7-4	30
"	E-2040-03120	5	30
16 MAR 75	E-2053-02431	750316-2-5	70
17 MAR 75	E-2054-02485	750317-3-5	50
"	E-2054-02492	6	40
19 MAR 75	E-2056-03011	750319-5-7	30
"	E-2056-03013	8	30
21 MAR 75	E-2058-03112	750321-7-4	20
2 APR 75	E-2070-02401	750402-1-12	50
8 APR 75	E-2076-03112	750408-7-4	10
13 APR 75	E-2076-03114	750413-7-4	20

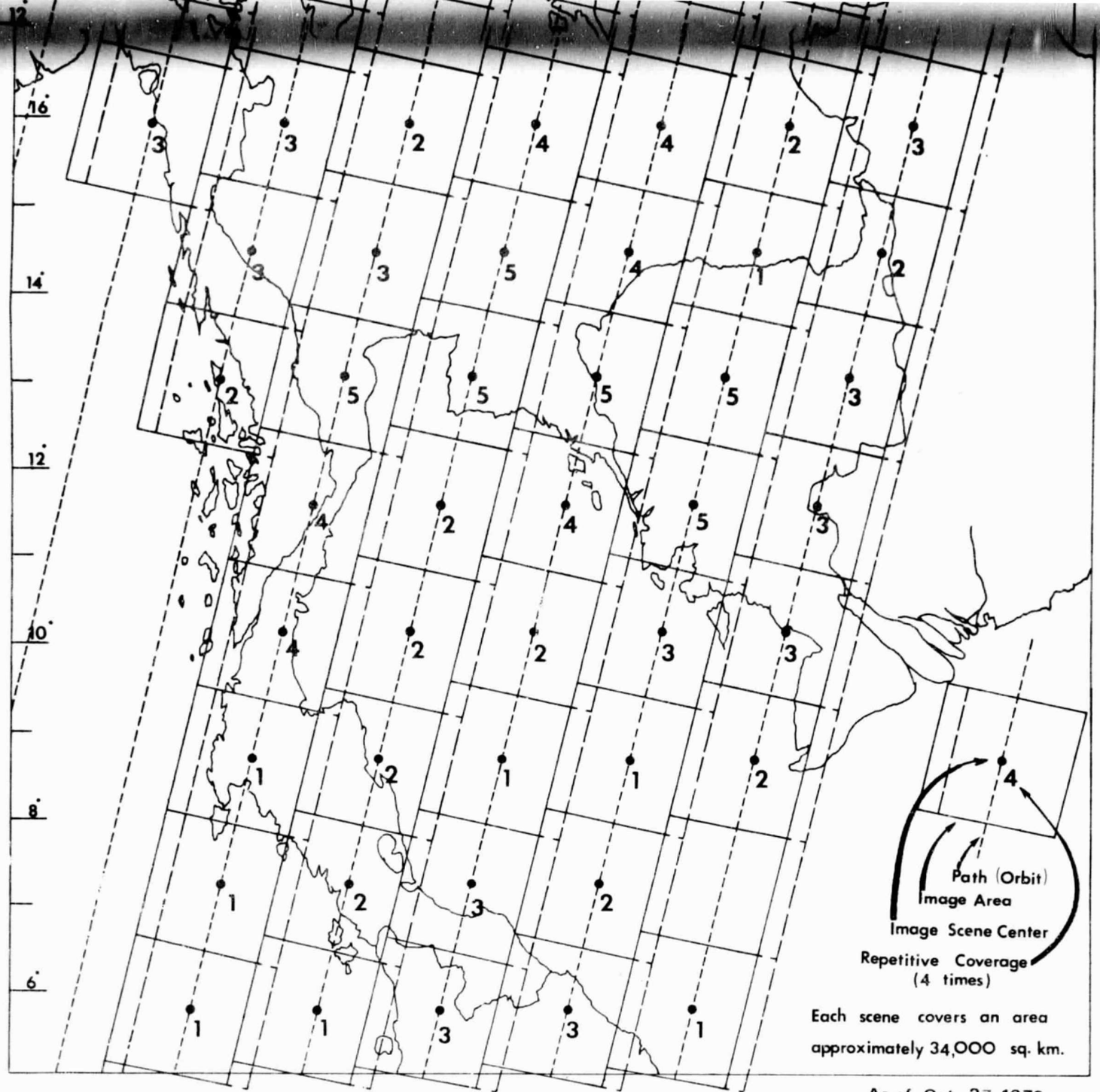
Comments

The data products of Landsat-2 received are mostly of good quality. Unfortunately, it took about 2 months since these data had been acquired before we received them and consequently they are not very useful in several areas of applications such as flooding, crop inventory etc. Besides, most of the areas are not covered in several repetition, as shown in the coverage map of Thailand, and part of the area covered with clouds. (The numbers indicated in the map include those purchased by TNRSP.)

In any case, it is encouraging that the whole coverage of Thailand were obtained and archived at TNRSP to be used by our investigators.

FOLDOUT FRAME





FOLDOUT FRAME 2

LANDSAT-2 COVERAGE OF THAILAND

THAILAND NATIONAL REMOTE SENSING PROGRAMME

As of Oct. 27, 1976

SCALE (Km)

0 50 100 150 200